APPENDIX B - HYDRAULICS

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APPENDIX B - HYDRAULICS

B.10 – HYDRAULIC CONSIDERATIONS

Appendix D begins with a general examination of various hydraulic terminology, computer aides and considerations and then moves into specific requirements and analysis for several technical aspects of hydraulic determinations.

B.10.01 Definitions Relating to Hydraulics

BASE FLOOD: The flood having a 1% chance of being exceeded in any given year, or a 100-year flood.

BASE FLOOD PLAIN: The area subject to flooding by the 100-year flood.

DESIGN FLOOD: The peak discharge, volume (if appropriate), stage, or wave crest elevation of the flood associated with the probability of exceedance selected for the design of a highway encroach¬ment. By definition, the highway will not be inundated by the design flood.

ENCROACHMENT: A highway and/or appurtenant feature within the limits of a flood plain. Encroachments may be transverse or longitudinal. A transverse encroachment is one that crosses the flood plain, such as a highway bridge project. A longitudinal encroachment is one that extends along the flood plain, such as a highway project along a river.

FEMA: Federal Emergency Management Agency

FHBM: Flood Hazard Boundary Map

FIRM: Flood Insurance Rate Map

FREEBOARD: The vertical clearance of the lowest structural superstructure above the water surface elevation of the overtopping flood.

NATURAL AND BENEFICIAL FLOOD PLAIN VALUES: Including (but are not limited to) fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater discharge.

NFIP: National Flood Insurance Program

OVERTOPPING FLOOD: The flood described by the probability of exceedance and water surface elevation at which flow occurs over the highway, over the watershed divide, or through structures provided for emergency relief.

REGULATORY FLOODWAY: The flood plain area that is reserved in an open manner by federal, state, or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designed amount (not to exceed one foot as established by FEMA for administering the National Flood Insurance Program).

RISK: The consequence associated with the probability of flooding attributable to an encroach¬ment. It shall include the potential for property loss and hazard to life during the service life of the highway.

RISK ANALYSIS: An economic comparison of a design alternative using expected total costs (construction costs plus risk costs) to determine the alternative with the least total expected cost to the public. It shall include probable flood-related costs during the service life of the facility for high¬way operation, maintenance, and repair for highway aggravated flood damage to other property and for additional or interrupted highway travel.

SCOUR REVIEW FLOOD: The overtopping flood or greatest flood drainage structures where overtopping is not practicable. The greatest flood used in the analysis is subject to a state-of-the-art capability to estimate the exceedance probability. This "greatest flood" shall be limited to a 500-year flood.

SIGNIFICANT ENCROACHMENT: A highway encroachment and any direct support of likely base flood plain development that would involve one or more of the following construction or flood-related impacts:

- A significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route.
- A significant risk.
- A significant adverse impact on natural and beneficial flood plain values.

SUPPORT BASE FLOOD PLAIN DEVELOPMENT: To encourage, allow, serve, or otherwise facilitate additional base flood plain development. Direct support results from an encroachment, while indirect support results from an action out of the base flood plain.

B.10.02 PC Programs. The following hydraulic programs are available in Roadway Design for use by the districts:

- HEC-RAS (River Analysis System)

  Water surface program produced by the Corps of Engineers. This program should be used for all bridge and open channel hydraulics, bridge scour calculations, etc.

- HYDRAIN

  A compilation of several hydraulic programs produced by a joint effort of several states including Idaho. The following programs are included:

  - HYDRO

    A command line hydrology program that uses the rational, U.S. Geological Survey Regression, and log-Pearson Type III methods to determine the peak flow for a site. This program also develops >n IDF curve for any location in the United States.

  - NFF

A compilation of statewide regression equations.

- HYDRA

A command line gravity pipe network hydraulics program that can be used either to analyse an existing storm drain/sanitary sewer system or design a new system.

- HYCHL

A command line as well as an intersection program that assists in the analysis and design of roadside channels and riprap lining.

- WSPRO

A command line step backwater program for natural channels with an orientation to bridge constrictions.

- HY8

An interactive and user-friendly program for design of highway culverts, design of energy dissipators, storm hydrograph generation, and reservoir routing upstream of a culvert.

B.10.03 Scour, Riprap, and Stream Stability. Scour, riprap, and stream stability are discussed in the following references which can be found www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm

(Hydraulic Engineering - General Publications):

- Drainage Design III, Open Channels, ITD
- Hydraulic Analysis for the Location and Design of Bridges, Highway Drainage Guidelines, AASHTO
- HRE Highways in the River Environment
- HEC 11 Design of Riprap Revetment
- HEC 15 Design of Roadside Channels with Flexible Linings
- HEC 18 Evaluating Scour at Bridges
- HEC 20 Stream Stability at Highway Structures
- HEC 23 Bridge Scour and Storm Instability Countermeasures

B.10.04 Hydraulic Concept Studies. Collect available data on runoff, discharges, flood plains, and alternative highway locations from:

- Alternative highway alignment maps.
- National Flood Insurance Program maps.
- Previous highway drainage studies.
- High-water marks.

- USGS, COE, etc., report.
- Location of water courses.
- Drainage areas.
- Present and future land uses.

  Determine runoff and discharges for waterway crossings on each alternative highway alignment from (determine for normal design flood and for 100-year flood):

- Existing studies.
- Computations.

Determine 100-year flood plain from:

- Existing studies.
- National Flood Insurance Program maps.
- Computation of elevations and boundaries as necessary to assess risk.

B.10.05 Analysis of Highway Alternatives. Identify encroachments on all 100-year flood plains.

Identify impacts of alternative alignments on the 100-year flood plain:

- Environmental.
- Risk.
- Support flood plain development.
- If impacts are large, measures to minimize, restore, and preserve natural and beneficial flood plain values.

  Identify National Flood Insurance Program status and constraints on flood plain encroachments (see following section).

  Identify significant flood plain encroachments, as necessary. Determine size of drainage structure:

- A significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route.
- A significant risk.
- A significant adverse impact on natural and beneficial flood plain values.

Evaluate alternative alignments to avoid longitudinal and significant encroachments in 100-year flood plains.

Coordinate studies with federal, state, and local water resource/environmental agencies.

Through public hearing notices, advise the public of significant encroachments under consideration.

Identify all 100-year flood plain encroachments in public hearings.

B.10.06 Draft Environmental Document. Review issues raised through public involvement procedures. For projects being processed as a categorical exclusion, document results of any concept studies, public involvement, etc., are required in the project records.

Present results of studies in draft environmental review document:

- Include an exhibit that displays both the alternatives and the approximate 100-year flood plain, as appropriate. Data from FEMA maps must be used, if available.
- Summarize the results of the concept hydraulic studies for each alternative.
- Indicate the consistency with existing or proposed regulatory floodways and the appropriate coordination (see the following section).
- Discuss the practicability of alternatives to significant encroachments.

B.10.07 Final Environmental Document. Review issues raised through public involvement procedures. Reevaluate the alternatives on the basis of the comments received and the water resources concerns, including potential support of any incompatible flood plain development.

After selection of the preferred location alternative for the final environmental document, review the alignment to see if any further efforts can be made to minimize encroachments or their im¬pacts, considering input from the public and review agencies. Review the adequacy of hydrologic and hydraulic studies for assessment purposes, expanding them as necessary.

Prepare responses to the comments received. Meet with water resources agencies and the public, as necessary, to attempt to satisfy concerns.

Prepare a discussion of the flood plain impacts (including an "only practicable alternative finding," if appropriate, for significant encroachments).

Document the results of the preliminary hydraulic location studies and any commitments made in the environmental process. Make this information available to designers for use in further project development.

Make an "only practicable alternative finding" available to regional planning agencies.

B.10.08 Design Studies.

Obtain the alignment and profile of the selected alternative.

Review commitments made in environmental documents and document constraints.

Review National Flood Insurance Program maps and flood plain zoning. www.fema.gov

Prepare the hydrologic analyses for the project and for specific appropriate sites:

- List the available flood-frequency records, flood studies, etc.
- Evaluate the potential for changes in watershed characteristics that would change magnitude of flood peaks, e.g., urbanization, channelization, etc.
- Plot the flood-frequency curve.
- Determine the distribution of flood and velocities for several discharges or stages in the natural channel for existing conditions.
- Plot the stage-discharge-frequency curve.

  Determine the need for a site map, which is used for estimating flood flow distribution, selecting cross sections of a stream, showing locations of the proposed encroachment and structure(s), and indicating the existing features (stream controls, encroachments, development and highway structures, etc.).
- Specially prepared map showing contours, vegetation, and improvements.
- In some cases, cross sections normal to flood flow are acceptable in lieu of a map. Determine the number of sections necessary.

  Use survey data to select encroachments to review in the field and initiate a survey data report that includes the following:
- Photographs (showing existing structures, past floods, main channel, and flood plain) to document existing conditions and to use in assigning resistance values.
- Comments on drift, ice, nature of streambed, bank stability, bend meanders, vegetation cover, and land use.
- Factors affecting water stages, such as high water from other streams, reservoirs (existing or proposed and approximate date of construction), flood control projects (give status), and other controls.
- Locations and elevations of high-water marks along stream, giving dates of occurrence.
- The relative importance and/or value of the adjacent property and, where appropriate, a list of facilities susceptible to flooding and first-flood elevations.
- Features that are constraints to modifying the upstream water surface elevation.
- The evaluation of the need for riprap and/or scour protection, including the need for spur dikes, energy dissipaters, countermeasures, etc.
- The location of existing structures (including relief or overflow structures) with respect to the proposed crossing or encroachment (upstream, downstream, as well as the existing roadway) and describe each fully, giving the:
  - Type, including span lengths and number of spans, bent design, pier orientation, culvert size, and number of cells.
  - Foundation type (spread footing, piling. etc.) and depth.

  - Scour history at abutments, bents, culvert outlets; headcutting; and stream aggradation and degradation.
  - Cross section beneath structures, noting clearance to superstructure and skew with direction of the current during extreme floods (add to the survey party instructions).
  - Flood history, high-water marks (dates and elevation), nature of flooding (including overtopping), damages, and sources of information.
  - Damage from abrasion, corrosion, wing wall failure, and culvert end failure.
- Site map preparation.

A field review should be performed by the designer to review all the locations that will require drainage structures.

B.10.09 Hydraulic Analyses. For each encroachment, determine the appropriate method for studying the design alternatives: mathematical model, physical model, or both.

Rate the capacity of the existing features and, if necessary, adjust the stage-discharge-frequency relationship.

Prepare the design of the bridge waterways:

- Identify the features that are constraints to modifying the upstream water surface elevation:
  - Land use.
  - Development.
  - Watershed divides.
  - Flood plain values, e.g., wetlands, etc.
- Determine the navigation requirements and evaluate the need for channel modifications and controls.
- Compute the backwater for various bridge lengths, approach profiles, and discharges:
  - Review the flow distribution and consider the need for auxiliary structures.
  - Plot the data as a family of curves on the stage-discharge-frequency curve developed for the existing conditions.
- Design the encroachments using minimum criteria and evaluate and document the risks.
- Calculate the contraction scour and scour depth at piers. Attach copy of HEC-RAS scour analysis report.
- Do not calculate bridge abutment scour. Calculate appropriate riprap size, blanket thickness for detail to protect bridge abutments, and attach to the Hydraulic Report.

- Design the embankment, bank, and channel protection and scour attenuation devices, if required. Investigate the need for the design spur dikes.

  Prepare the design culverts:

- Identify the features that are constraints on headwater elevation and highway profile.
- Evaluate the abrasion and corrosion potential (see Figure 6-2):
  - Eliminate from consideration the materials that will give unsatisfactory service life.
  - Choose the protective measures.
- Compute and plot the performance curves for trial culvert sizes.
- Evaluate the need and provisions for fish passage.
- Select the culvert design:
  - Design encroachments using minimum criteria.
  - Evaluate and document risks.
- Determine the hydraulically equivalent sizes for bid alternatives.
- Evaluate the need and design for debris control.
- Evaluate the need and design for outlet protection.
- Investigate the need and design for protection against failure by buoyancy and/or by separation at joints.

  Prepare the design of longitudinal encroachments. Determine the navigation requirements and evaluate the need for channel modifications and controls:

- Determine the effect of the proposed encroachment on water-surface profiles using various roadway profile alternatives.
- Design the encroachments using minimum criteria and evaluate and document the risks.
- Evaluate the effects on scour and deposition in channel and tributaries.
- Design the embankment, bank, and channel protection.

B.10.10 Documentation. Show the final layout of encroachments in the plan and profile, including the magnitude, elevation, and exceedance probability of the scour review flood and the base flood, if appropriate (the overtopping flood for interstate mainlines shall not be less than the 50-year flood).

Complete project files should include:

- Hydrologic and hydraulic data and design computations.
- As appropriate, information on:

- The need for emergency supply and evaluation routes.
- Hydraulic controls that affect the proposed drainage structure.
- Constraints imposed by requirements for highway geometrics.
- Navigation requirements.
- Channel modification.
- Effects on stream stability.
- Effects on stream ecology.
- The need for stream controls to protect highway.
- The need and provisions for fish passage.
- Consistency with the National Flood Insurance Program.

See Figure B-1 for the hydraulics report outline.

Figure B-1

HYDRAULICS REPORT OUTLINE

A. Existing Structure
   1. Vicinity sketch
   2. Problems and adverse conditions
      a. Scour
   3. Stream stability
   4. Photos - Aerial (if available) and ground
   5. Hydrology
      a. Floods
         (1) Design - 50-year
         (2) Flood insurance consistency - 100-year
         (3) Scour design - 100-year
         (4) Scour review - Lesser of overtopping or 500-year
      b. Methods
         (1) Gage data - 20 years of records or more, including a log-Pearson printout
         (2) Four U.S. Geological Survey methods, including data
   6. Hydraulics
B. Proposed Structure
   1. Hydraulics - Include calculations or computer printout
   2. Problems and adverse conditions - Solutions
   3. Information (as appropriate) on:
      a. Hydraulic controls that affect the proposed structure
      b. Channel modification
      c. Effects on stream stability
      d. Need and provisions for fish passage
      e. Navigation requirements
      f. Need for stream controls to protect highway
         (1) Such as guide banks or trash racks
      g. Constraints imposed by highway geometrics
      h. Effects on stream ecology
      i. Need for emergency supply and evacuation routes
C. Evaluate Scour Data and Need for Riprap at Piers and Abutments
   1. Show typical section, size and toe detail
   2. Show placement
D. Site Map With Contours
E. Cross Sections
F. Permit Status and Consistency With Flood Insurance Requirements
G. ITD 210, Hydraulic Structures Survey
   1. Clearance

B.10.11 Deck Drainage. Slotted drains and embankment protectors can be used to intercept runoff at each end of a bridge. The length of the slotted drain or embankment protector can be determined from Figure 6-1 in Section 600.

The slotted drain or embankment protector lengths for super elevated roadways not covered in this table can be determined from the following equation:

$L_T = 0.6\ Q^{0.42} S^{0.3} (1/nSx)^{0.6}$

Where

L_T = Length of slotted inlet required to intercept 100% of the gutter flow in feet

Q = Discharge in cfs

n = Mannings n value of pavement (typically 0.016)

Sx = Cross slope of pavement in feet per foot

Slotted drains should terminate in a standard catch basin with a facility for removing sand (Standard Drawing D-1-B).

References: Urban Drainage Design Manual, HEC-22 FHWA-SA-96-078

Design of Bridge Deck Drainage, HEC-21 FHWA-SA-92-010

B.10.12 Culvert Design Guide. Establish drainage areas along the route-proposed alignment.

Determine the area by Planimeter, grid intersect, or other acceptable method.

Compute the design discharge:

- Watershed area >10 mi^2.

  Check for gage data - log-Pearson Type III

  U.S. Geological Survey reports,

  U.S. Geological Survey Water Resource Investigations 02-4170

  U.S. Geological Survey open file report #81-909, pp. 21-30

  U.S. Geological Survey open file report #93-419

  U.S. Geological Survey Water Resources Investigations 7-73

  U.S. Geological Survey Water Resources Investigations 80-32, pp. 33-36
- Watershed area <10 mi2 - small area nomograph.
- Rational method can be used on culverts for watersheds up to 200 acres
- NRCS TR-55 Method (Natural Resource Conservation Service)
- USGS 93-419, “Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States” (Arid Study)

Locate a possible culvert cross drain station and check FEMA for a possible flood insurance zone or regulatory floodway.

For the small area nomograph, i.e., <10 mi^2, determine:

- The elevation drop in the drainage (H).
- The length of drainage (L).
- The area of drainage (A).
- The design storm area classification.
- The runoff factor (Kt) for a thunderstorm, which requires time and Kb.

  Needed for Kb

  1. ground cover
  2. avg. side slopes
  3. exposure of watershed such as NE, West or South
- The snowmelt zone and the Kt for snowmelt.

Complete the small area nomograph for Q (pick the larger of the Qs for design) derived from:

- Thunderstorm
- Snowmelt

Establish the stage discharge diagram for tailwater from the cross section of stream and slope. Use the HY-8 of Hydrain, the Mannings Equation, or nomographs.

Determine the length of the slope and allowable headwater depth from the field data.

Determine the headwater from HY-8 or nomographs. Repeat the process for various sizes. Refer to FHWA HDS-5 for nomographs of various shapes.

Establish the stage discharge curve for the culvert, if necessary.

Check the minimum freeboard and determine the outlet velocity from H-P programs or Mannings formula.

Determine the need for outlet protection, FHWA, HY-8 Culvert Design Program, HEC-11 (pp. 11-6), HEC 14, and previous experience.

Determine the height and type of fill material, culvert material, required gage, if applicable, and other pertinent data.

Check for the existing culvert at the same station or near the station.

Talk with landowners and maintenance crews for problems, flooding, and over-the-ramp floods.

List the final determination on the Pipe Culvert Summary.

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B.10.13 Head Determinations.

Allowable Headwater

The allowable headwater is the difference in elevation above the inlet invert that water is allowed to rise in order to allow a given amount of water to flow through a culvert.

Drift and Ice

Trash racks can be installed in the event of unusual drift problems. However, they require periodic maintenance and should only be used where necessary. Highway Engineering Circular No. 9, Debris Control Structures, by the FHWA contains several designs for trash racks.

Minimum Freeboard To Subgrade

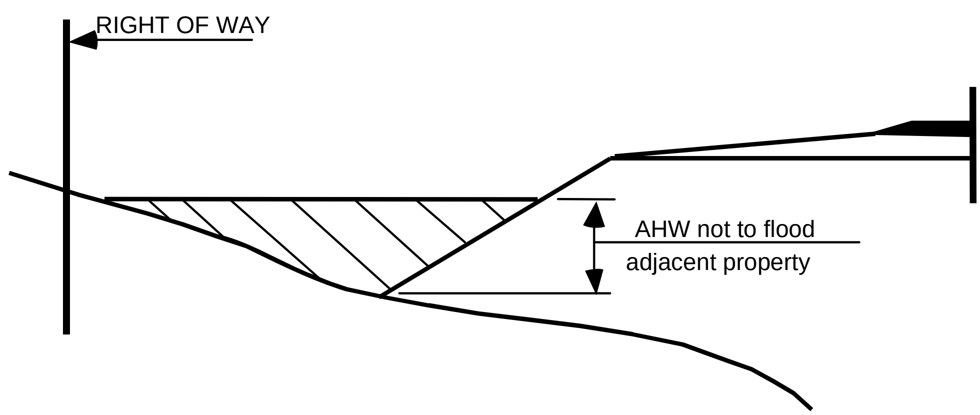
The allowable headwater (AHW) should not exceed the total head minus a freeboard of two feet to the bottom of the subgrade elevation. **(Subgrade elevation is interpreted to be the bottom of the aggregate base course.)** However, if the top of the pipe is less than 2.0’ below subgrade, then the allowable headwater shall not exceed the pipe diameter.

Embankment Material - Entrance Erosion

Depending on the embankment material used, headwater at pipe entrances can cause erosion. Additional head may reduce cost of installation if a smaller pipe diameter can be used. This savings is lost, however, if expensive erosion protection at the entrance must be provided. A brief economic analysis will give the desired solution.

Backwater on Adjacent Property

The allowable headwater shall not cause backwater of the design storm to accumulate beyond the right-of-way.



Where additional headwater would result in savings of pipe diameter, the price of purchasing additional right-of-way should be compared to the possible savings of installation costs.

In cases where adjacent properties consist of low value land, the extra right-of-way cost may well be less than larger pipe sizes.

B.20 – FLOOD PLAIN ENCROACHMENT

B.20.01 National Flood Insurance Program Constraints on Flood Plains. The National Flood Insurance Program (NFIP) was initiated to reduce future and recurring damages due to flooding. Every community located in a flood hazard area has the opportunity to participate in the program. The program makes subsidized flood insurance available to property owners at reasonable rates. A condition of participation is that each community must pass and enforce ordinances to control development in 100-year flood plains.

Every highway encroachment in an NFIP-identified 100-year flood plain must be located and designed to be consistent with ordinances that are passed to qualify a community for the NFIP. If this is not done, the affected community's participation in the program (subsidized insurance) is jeopardized.

A Floodplain Development Permit must be obtained from the community (city or county) for any encroachment in a 100-year floodplain. The floodplain development permit should accompany the ITD-210, Hydraulic Report submittal. If the community does not use a formal permit form, a letter from the community's Floodplain Ordinance Administrator approving the encroachment is acceptable. If the district is forwarding a consultant design, make sure the consultant has obtained the permit or letter before forwarding to Roadway Design.

If the encroachment is in the regulatory floodway, the new structure or replacement structure cannot increase the water surface elevation unless a Letter of Map Revision (LOMR) is processed through the Federal Emergency Management Agency (FEMA). A computer analysis may or may not be needed to verify this. Check with Hydraulics Engineer if a regulatory floodway is involved. Each community has a set of Flood Insurance Rate Maps (FIRM), Floodway Maps and Flood Insurance Studies (FIS) for use in making these determinations.

Any proposed encroachment in a 100-year flood plain must be evaluated to determine the NFIP status of the area and the constraints on encroachments. The following items are the various situations with corresponding constraints that will occur in a community participating in the NFIP. (Replacement of an existing bridge will be consistent with the NFIP if the waterway under the new bridge is equal to or greater than that of the existing bridge and no additional encroachment in the regulatory floodway is involved.)

1. A "Regulatory Floodway" Has Been Established (see FEMA maps, which are available from the Local jurisdiction (City or County)

    a. An encroachment is consistent with the regulatory floodway if the regulatory floodway is spanned in both vertical and horizontal dimensions – that is, there are no encroachments into the regulatory floodway.

    b. An encroachment can be consistent with the regulatory floodway if the only regulatory floodway encroachment is by bridge piers. Hydraulic calculations may show that the piers have no discernible effect and, if so, no compensation would be required. Channel or other improvements at the structure may be necessary to compensate for the pier encroachment.

c. An encroachment can be made consistent with the "regulatory floodway" by revising the regulatory floodway. Many regulatory floodways and flood plains were delineated without sufficient detail to accurately define their boundaries. Therefore, it may be prudent and cost effective to revise the floodway rather than meet the requirement of 1.a. or 1.b. A regulatory floodway may be revised by moving it horizontally. However, the following criteria will apply:

(1) Backwater cannot be increased – that is, the elevation of the top of the regulatory floodway (the water surface profile published in the flood insurance study) cannot be raised above the 1.0 foot maximum.

(2) The community and FEMA must agree to revision of the regulatory floodway.

d. When it is "demonstrably inappropriate" to design an encroachment to fit under 1.a., 1.b., or 1.c., an alternative regulatory floodway with increased backwater may be approved. However, this option should be considered only as a last resort.

e. For any of the above situations, encroachments in the flood fringe area are consistent with the NFIP. However, buildings constructed in the 100-year flood plain must be flood-proofed so the 100-year flood will not damage them.

2. A "Regulatory Floodway" Has Not Been Established (see FEMA maps)

a. In a flood plain shown on a Flood Insurance Rate Map (FIRM), where no regulatory floodway has been designated, highway encroachments should be designed to allow no more than a 1-foot increase in the base flood elevation based on technical data.

b. In a flood plain shown on a Flood Hazard Boundary Map, where no regulatory floodway has been designated, highway encroachments should be designed to allow no more than a 1-foot increase in the base flood elevation based on technical data.

c. In a flood plain shown on a FIRM, where no regulatory floodway has been designated, highway encroachments causing less than 1 foot of backwater for the delineated 100-year flood surface are acceptable.

3. Encroachment of Highway on Floodway

Where it is not cost effective to design a highway crossing to avoid encroachment on an established floodway, a second alternative would be a modification of the floodway itself. Often, the community will be willing to accept an alternative floodway configuration to accommodate a proposed crossing provided NFIP limitations on increases in the base flood elevation are not exceeded. This approach is useful where the highway crossing does not cause more than 1 foot rise in the base flood elevation. In some cases, it may be possible to enlarge the floodway or otherwise increase conveyance in the floodway above and below the crossing in order to allow greater encroachment. Such planning is best accomplished when the floodway is first established. However, where the community is willing to amend an established floodway to support this option, the floodway may be revised.

The responsibility for demonstrating that an alternative floodway configuration meets NFIP requirements rests with the community. However, this responsibility may be borne by the agency proposing to construct the highway crossing. Floodway revisions must be based on the hydraulic model that was used to develop the currently effective floodway but updated to reflect existing encroachment conditions. This will allow determination of the increase in the base flood elevation that has been caused by encroachments since the original floodway was established.

Alternate floodway configuration may then be analyzed. Base flood elevation increases are referenced to the profile obtained for existing conditions when the floodway was first established.

Data submitted to FEMA in support of a floodway revision request should include the following:

a. Copy of the current regulatory Flood Boundary Floodway Map showing existing conditions, proposed highway crossing, and revised floodway limits.

b. Copy of computer printouts (input, computation, and output) for the current 100-year model and current 100-year floodway model.

c. Copy of computer printouts (input, computation, and output) for the revised 100-year floodway model. Any fill or development that has occurred in the existing flood fringe area must be incorporated into the revised 100-year floodway model.

d. Copy of the engineering certification is required for work performed by private subcontractors.

The revised and current computer data required above should extend far enough upstream and downstream of the floodway revision area in order to tie back into the original floodway and profiles using sound hydraulic engineering practices. This distance will vary depending on the magnitude of the requested floodway and the hydraulic characteristics of the stream.

A floodway revision will not be acceptable if development that has occurred in the existing flood fringe area since the adoption of the community's floodway ordinance will now be located within the revised floodway area unless adversely affected adjacent property owners are compensated for the loss.

If the input data representing the original hydraulic model are unavailable, an approximation should be developed. A new model should be made using the original cross section topographic information, where possible, and the discharges contained in the Flood Insurance Study that establish the original floodway. The model should then be run confining the effective flow area to the currently established floodway and calibrated to reproduce, within 0.10 foot, the "With Floodway" elevations provided in the Floodway Data Table for the current floodway. Floodway revisions may then be evaluated using the procedures outlined above.

4. Floodway Encroachment Where Demonstrably Appropriate

When it would be demonstrably inappropriate to design a highway crossing to avoid encroachment on the floodway and where the floodway cannot be modified such that the structure could be excluded, FEMA will approve an alternate floodway with backwater in excess of the one foot maximum only when the following conditions have been met:

a. A concept study has been performed and FHWA finds the encroachment is the only practicable alternative.

b. The constructing agency has made appropriate arrangements with the affected property owners and the community to obtain flood easements or otherwise compensate them for future flood losses due to the effects of the structure.

c. The constructing agency has made appropriate arrangements to ensure that the National Flood Insurance Program and Flood Insurance Fund do not incur any liability for additional future flood losses to existing structures that are insured under the program and grandfathered in under the risk status existing prior to the construction of the structure.

d. Prior to initiating construction, the constructing agency provides FEMA with revised flood profiles, floodway and flood plain mapping, and background technical data necessary for FEMA to issue revised Flood Insurance Rate Maps and Flood Boundary and Floodway Maps for the affected area upon completion of the structure.

5. Flood Plain Encroachment

ITD 2792, Summary of Flood Plain Encroachment, is a format that may be used to summarize the results of a flood plain encroachment study. ITD 2665, Floodway Revision Requirement, should be used when it is necessary to revise a regulatory floodway.

6. Temporary Construction

Temporary construction, such as forms, coffer dams, retaining walls, etc., within a Regulatory Floodway must be approved by the local government. The rise in water surface elevation must be limited to 0.2 to 0.3 foot. The construction should be scheduled so all restrictions will be removed by November 1, if possible.

Temporary crossings are considered as temporary construction and can only be left in for 12 months. The floodway must be revised according to FEMA regulations (www.fema.gov) if the crossing is left in more than 12 months (see Figure B-2).

Figure B-2

Memorandum

U.S. Department of Transportation
Federal Highway Administration

Room 312 Mohawk Building
708 S.W. Third Avenue
Portland, Oregon 97204

Subject: Temporary Construction In Floodways

Date: August 10, 1989

530

FHWA - IDAHO DIVISION
AUG 14 1989

	DIV ADMIN	/	AREA ENGR 1
5	CA SEC	/	AREA ENGR 2
/	ASST DIV AD	/	AREA ENGR 3
/	FIELD OPS	/	ASST BR ENG
	PLANNER		ENC
	ROW UNI		SI 1
	FIN MGR		SI 2
	FIN SP		SI 3
	FISCAL CLK		DMCS SEC
	FILE		

From: J. P. Clark
Deputy Regional Administrator

Reply to Attn of: HST-010.3
File: 530.

To: DIVISION ADMINISTRATORS
Mr. R. E. Ruby, Juneau, Alaska (HBR-AK)
Mr. J. T. Coe, Boise, Idaho (HFO-ID)
Mr. D. E. Wilken, Salem, Oregon (HBR-OR)
Mr. B. F. Morehead, Olympia, Washington (HBR-WA)

and Mr. J. N. Hall, Division Engineer
Western Federal Lands Highway Division (HDF-17.221)
Vancouver, Washington

Due to a recent inquiry from the Idaho Division, we requested that FEMA provide us with some guidance regarding temporary construction practices and also temporary crossings in regulatory floodways. Attached is their regional response which was also sent to their Headquarters Office for confirmation.

To summarize, strict interpretations of FEMA's regulations makes no allowances for temporary structures. They are handled the same as permanent structures, i.e., if cofferdams or falsework, etc., creates more than the allowable amount of backwater, floodway and ensuing map revisions are required. However, FEMA does provide some latitude when temporary construction or structures are considered. They feel that the only reasonable course of action is to have the local government permit the final structure design regardless of the shape or timing of the temporary construction practice. Otherwise, there would be lengthy delays while map revisions were made for the temporary structures and then again when the falsework, etc., was removed and the final structure was in place. It is this offices opinion that the FEMA policy is reasonable and prudent.

Additionally, we concur with FEMA's recommendations that preliminary calculations should be made by the constructing agency to assure that the backwater effects created by the temporary structure or construction ~~is~~ are within tolerable limits: a 0.2' or 0.3' rise. Also, if at all possible, construction practices should occur during low flow months; June 1 through October 31. Finally, it is FEMA's opinion that any increased flooding caused by temporary construction is the responsibility of constructing agency. Therefore, it is recommended that the policies stated in their August 3, 1989 letter be strictly followed.

If further guidance is provided by FEMA's Headquarters office, I will be sure to forward it on to you. Also, if you have any comments or questions, please call.

Christopher N. Dunn

Christopher N. Dunn, P.E.
Hydraulic Engineer

Attachment

B.30 – TECHNICAL DATA

B.30.02 Small Areas Nomograph. Tables and nomographs of Figures B-3 and B-5 and the following information can be used to determine the design discharge for small areas.

The nomograph gives maximum discharge for both snowmelt and thunderstorm runoff. Runoff is figured for both cases and the higher discharge is used.

B.30.03 Thunderstorm Runoff. The following information must be obtained (the first three factors can be determined from aerial photos and contour maps, the fourth factor can be determined from the map on the nomograph, and the fifth factor can be determined from Figure B-4):

1. Elevation drop in the drainage (H).
2. Length of the drainage (L).
3. Area of the drainage (A).
4. Design storm area classification (Area I, II, or III).
5. Runoff factor (Kt).

B.30.04 Snowmelt Runoff. The following information must be obtained:

1. Snowmelt zone (Zone A, B or C).
2. Area of drainage (A).
3. Runoff factor (Kt).

The snowmelt zone is determined from Figure B-5, the area of drainage is determined from aerial photos and contour maps, and the runoff factor is determined from the following information:

1. Runoff factors (snowmelt).
2. Assume the basic runoff factor for snowmelt to be 55 percent.

Figure B-3

RUNOFF FACTORS

THUNDERSTORMS

FINAL Q VALUES FROM NOMOGRAPH WILL BE CONVERTED FROM CU. FT./SECOND TO CU. METERS/SECOND

TABLE FOR RUNOFF VALUES - K_b

		Average side slopes				
		0%	25%	50%	75%	100%
Vegetative Ground Cover	200%	5	10	20	30	40
	150%	10	20	30	40	50
	100%	17	30	40	50	60
	50%	22	35	50	60	70
	10%	27	39	52	62	78
	0%	30	40	55	67	80

"Vegetative ground cover" = $\frac{\text{Area of leaves, needles}}{\text{Area of ground}}$

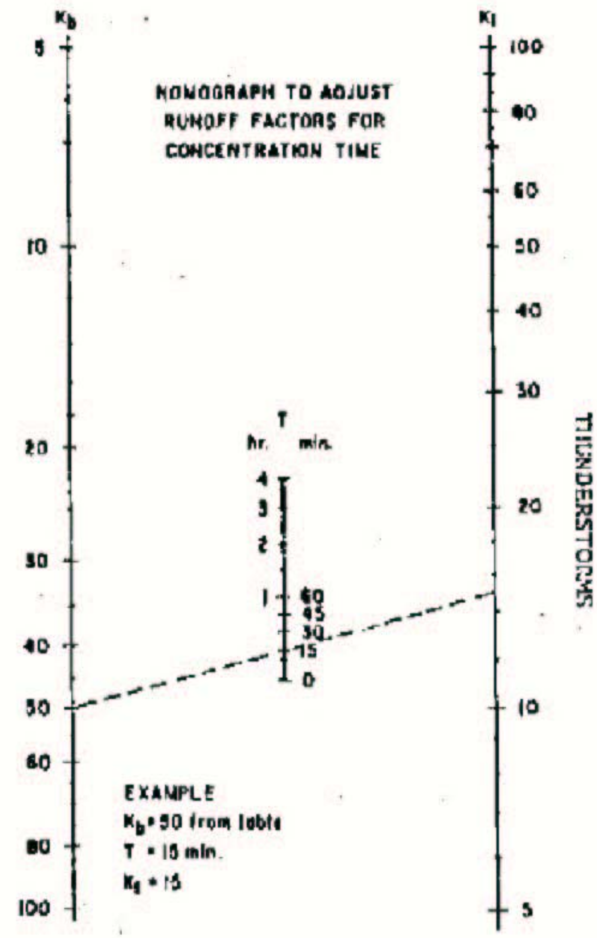
Ex:		
	Closed stand of timber	200%
	Pasture land	75-150%
	Cheat Grass	15-50%
	Sagebrush	20-60%
	Wheat field	0-50%

Modification for infiltration:

Granular - Chohesionless soils	0.5 - 0.7
Silt, loam	0.9 - 1.1
"Heavy" soils, clay	1.3 - 1.5

Example: Ground cover is cheat grass, with average side slopes of 50% and the soil type is loam 50% vegetative ground cover and 50% side slope gives a K_b of 50 from the table. Modification for infiltration 1 (for loam). K_b is equal to 50.

Example: (Thunderstorm) See figures 456-03



A culvert site in Area I is 4,500 ft. downstream and 700 ft. lower than the most remote point on the watershed. The tributary basin has an area of 500 acres, and the average ratio of runoff to precipitation (Kt) is found to be 15% as shown on Nomograph. The line passes through H = 700 ft., L = 4,500 ft., I = 1.9., A = 500 ac., P = 1000., Xt = 15 and results in Q = 140 Cu. Ft./Second.

Figure B-4

DESIGN HYDRAULICS APPENDIX D

Figure D-4

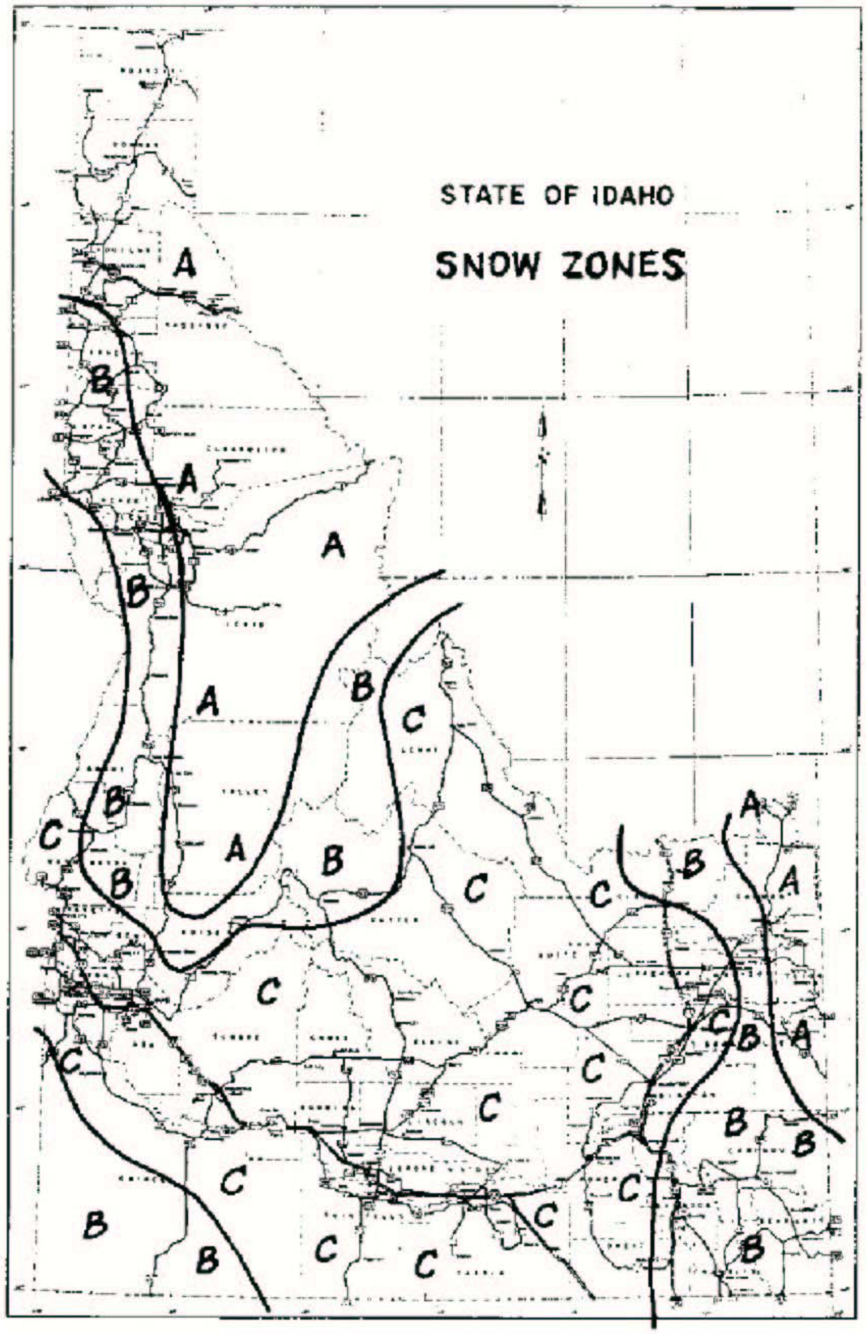
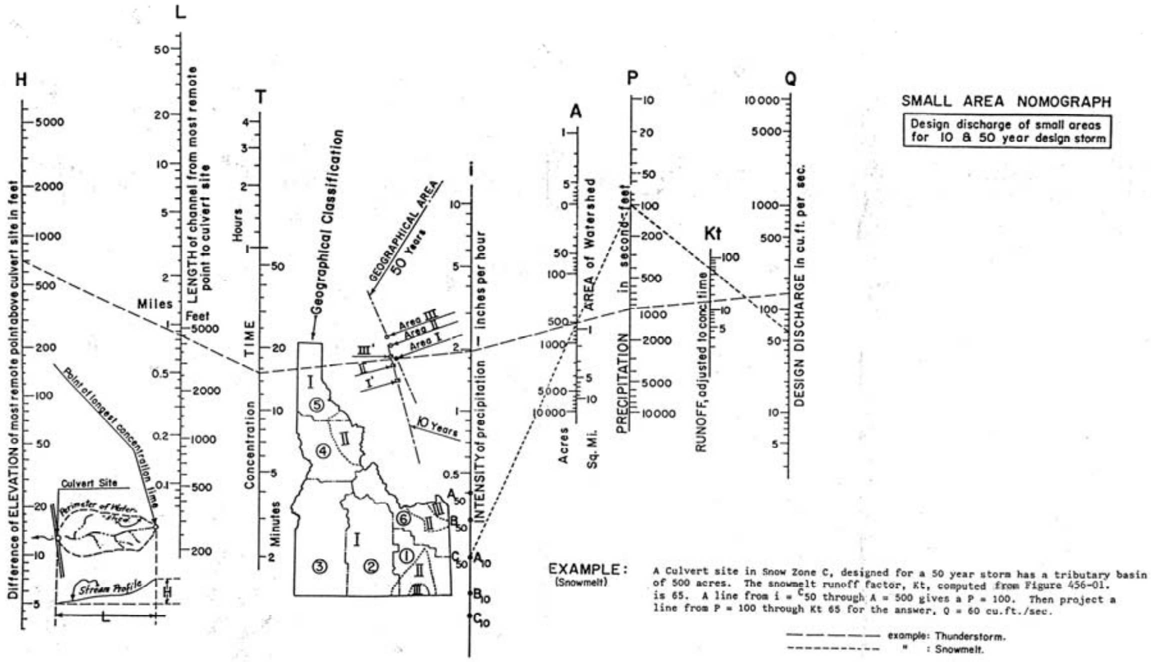


Figure B-5

Figure 456-03



400-158

B.30.05 Discharge Determination.

Step One: Determine:

- Exposure of watershed, e.g., NE.
- Vegetative ground cover of watershed (see Figure B-3).
- Area of watershed.

Step Two: Add to the basic runoff factor the following amounts, depending on average exposure, as follows:

- N 0%
- NE, NW 2%
- E, W 4%
- SE, SW 6%
- S 8%

Step Three: Add the following amounts depending on vegetative ground cover, as follows:

- 200% 0%
- 150% 4%
- 50% 8%
- 0% 12%

Use weighed averages if distribution is uneven.

Step Four: Add the following amounts depending on the area of the watershed, as follows:

- 0 - 2 square miles 10
- 2 - 5 square miles 6
- 5 - 8 square miles 3
- over 8 square miles 0

Example: A NW exposed watershed with average vegetative ground cover of 120 percent contains 6.5 square miles.

Runoff factor (K_t) is 55 + 2 + 5 + 3 = 65

B.30.06 Snowmelt Zones. Very little is known of the rate of snowmelt throughout Idaho. Before snow can melt, heat has to be transferred from the atmosphere or the soil into the snow layers. The laws governing this heat exchange are rather complex. Snow melts rapidly when air temperatures and wind velocities are high.

Idaho has been divided into three different snowmelt zones. Again, this information is used when computing snowmelt runoff by the "Small Area Nomograph" method. Figure B-4 shows the location of these three snowmelt zones.

B.30.07 Flood Type Zones. Major streams in Idaho have their peak discharge in winter or spring. These high discharges are caused by snowmelt or a combination of rain and snowmelt. When analyzed, the cause of high discharges for small watersheds, particularly in southern Idaho, have their maximum runoff in summer as a result of convective storms.

In some isolated areas, drainage problems exist not so much because of the high discharges but because the terrain is so flat that water simply cannot get away fast enough.

Finally, in other areas of Idaho, drainage problems are directly related to the flow of irrigation and irrigation-drainage water. Figure B-6 shows various causes for floods in small watersheds. This map does not show all the details, but the designer can use it to determine the principal causes of floods in the immediate area of a project.

B.30.08 Basic Data. Based on U.S. Weather Bureau records, Idaho has been divided into different intensity-duration-frequency (IDF) zones. The map in Figure B-7 shows the different areas. The graphs (nine pages) in Figure B-8 give IDF information for each zone.

When using these graphs, it must be kept in mind that the data from which they are drawn are sporadic and much more information is needed for short-duration storms in order to arrive at more definitive answers. These graphs provide various rainfall intensities depending upon the length of the storm and the return period.

IDF curves were used as a basis for the Small Area Nomograph (Figure B-5) for runoff based on precipitation.

Figure B-6

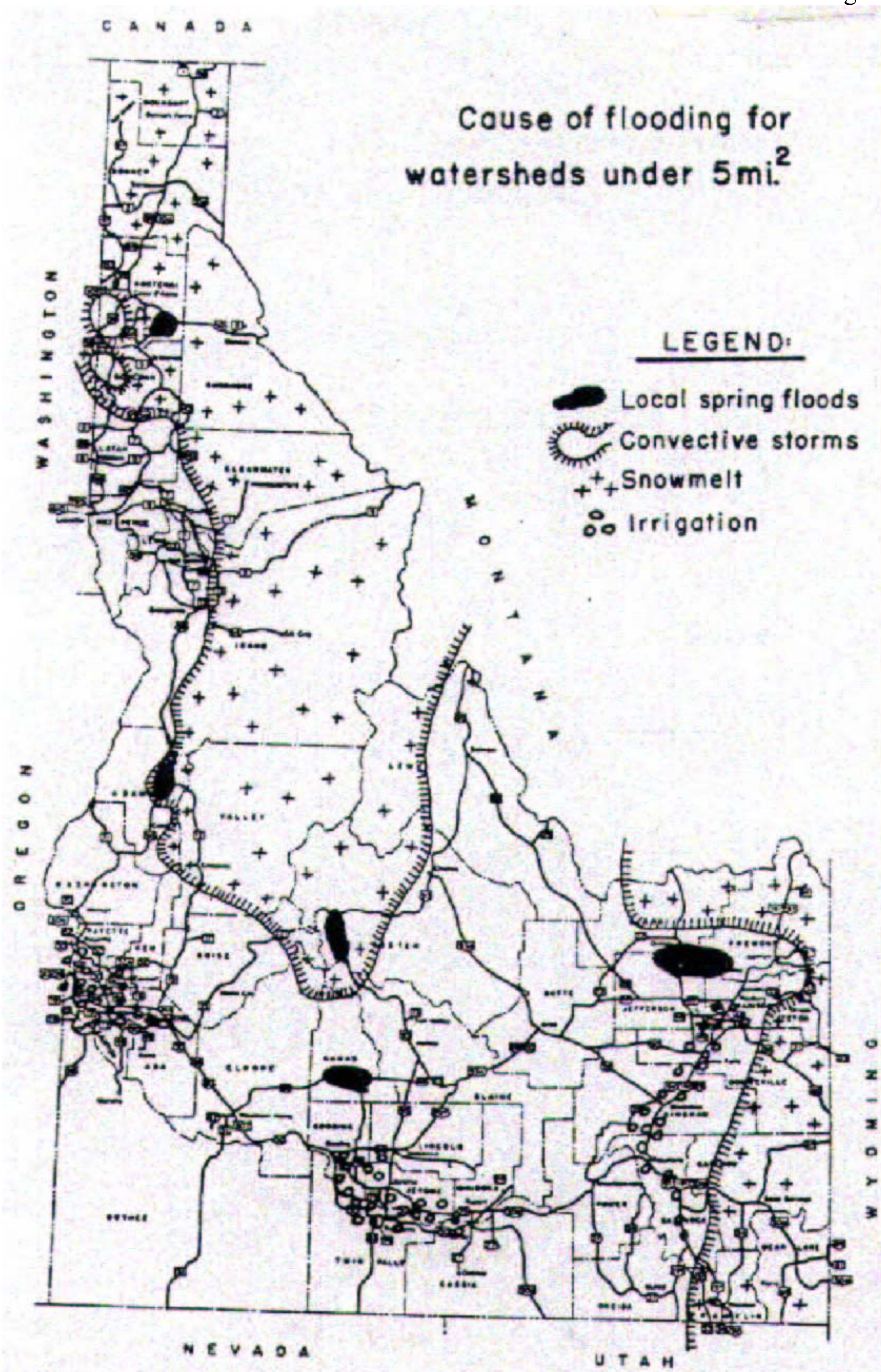

CANADA
Cause of flooding for watersheds under 5mi.²
LEGEND:
Local spring floods
Convective storms
Snowmelt
Irrigation
WASHINGTON
OREGON
MONTANA
WYOMING
NEVADA
UTAH

Figure B-7

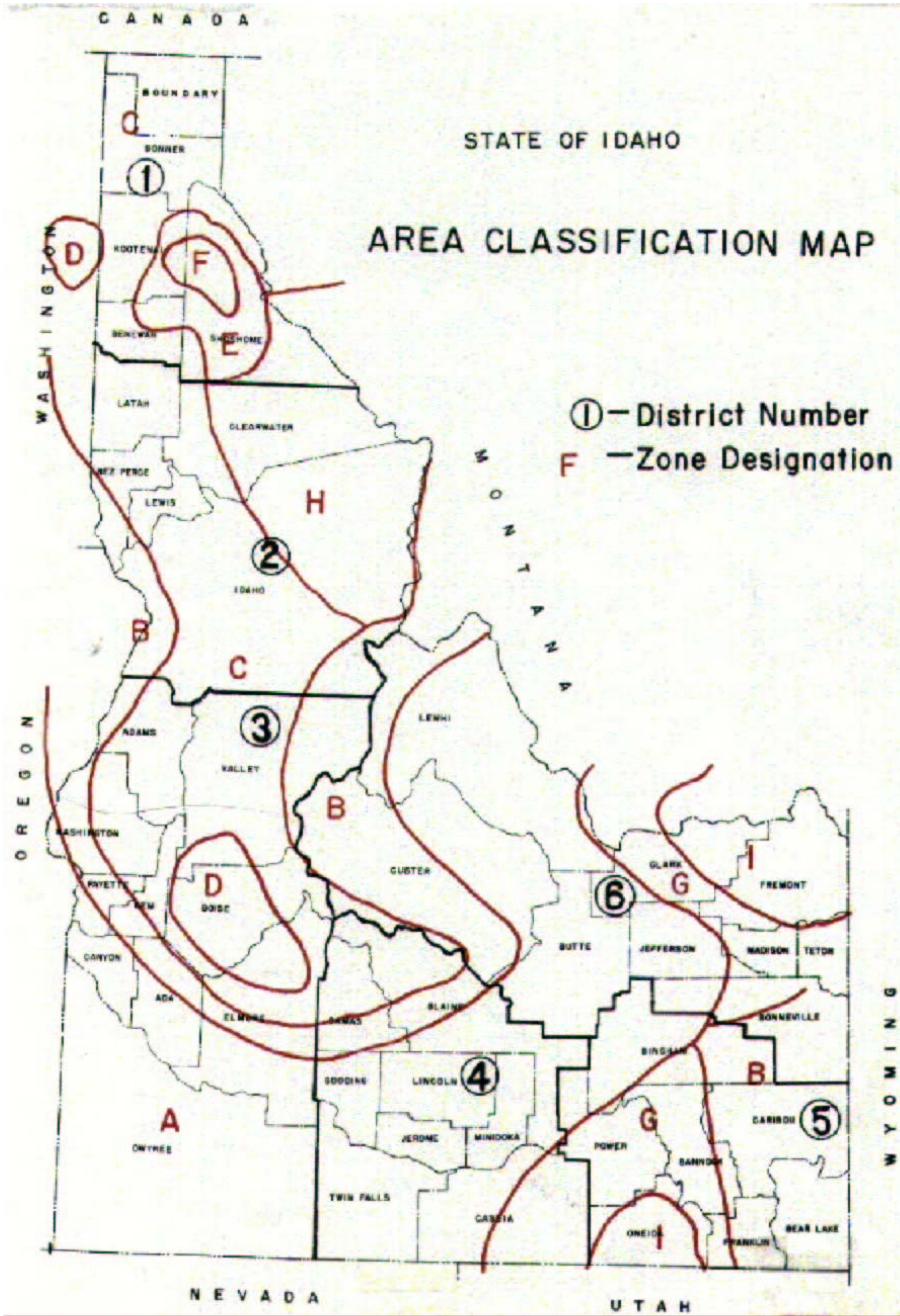

CANADA
STATE OF IDAHO
AREA CLASSIFICATION MAP
① – District Number
F – Zone Designation
WASHINGTON
MONTANA
OREGON
WYOMING
NEVADA
UTAH
BOUNDARY
BONNER
LATAH
CLEARWATER
NEZ PERCE
LEWIS
IDAHO
ADAMS
VALLEY
WASHINGTON
LEMHI
CUSTER
CLARK
FREMONT
BOISE
CANYON
ADA
ELMORE
BUTTE
JEFFERSON
MADISON
TETON
BONNEVILLE
BLAINE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
CARIBOU
OWYHEE
POWER
BANNOCK
TWIN FALLS
CASSIA
ONEIDA
FRANKLIN
BEAR LAKE
A
B
C
D
E
F
G
H
I
1
2
3
4
5
6

Figure B-8
Figure 1 of 9

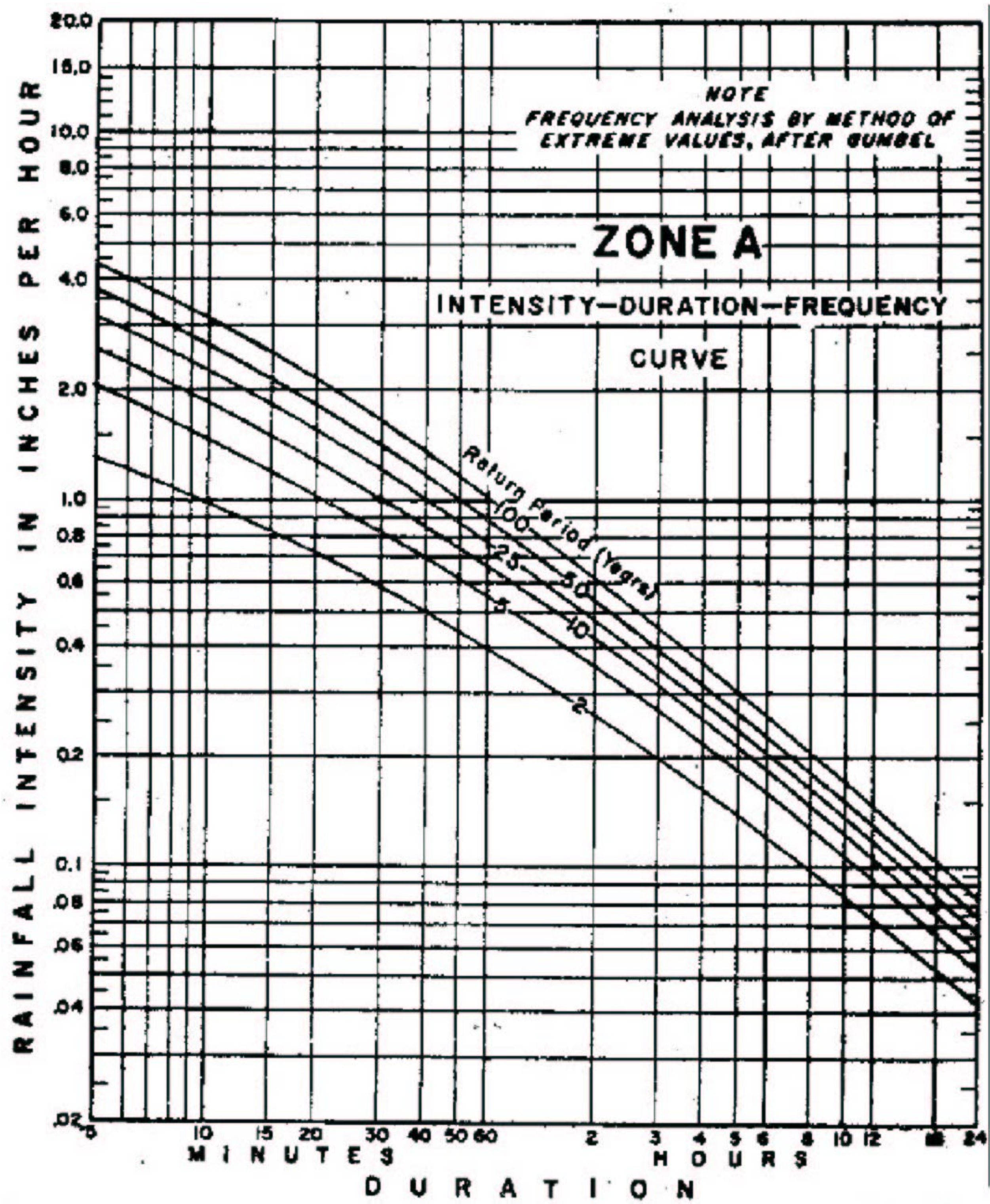


Figure B-8
Page 2 of 9

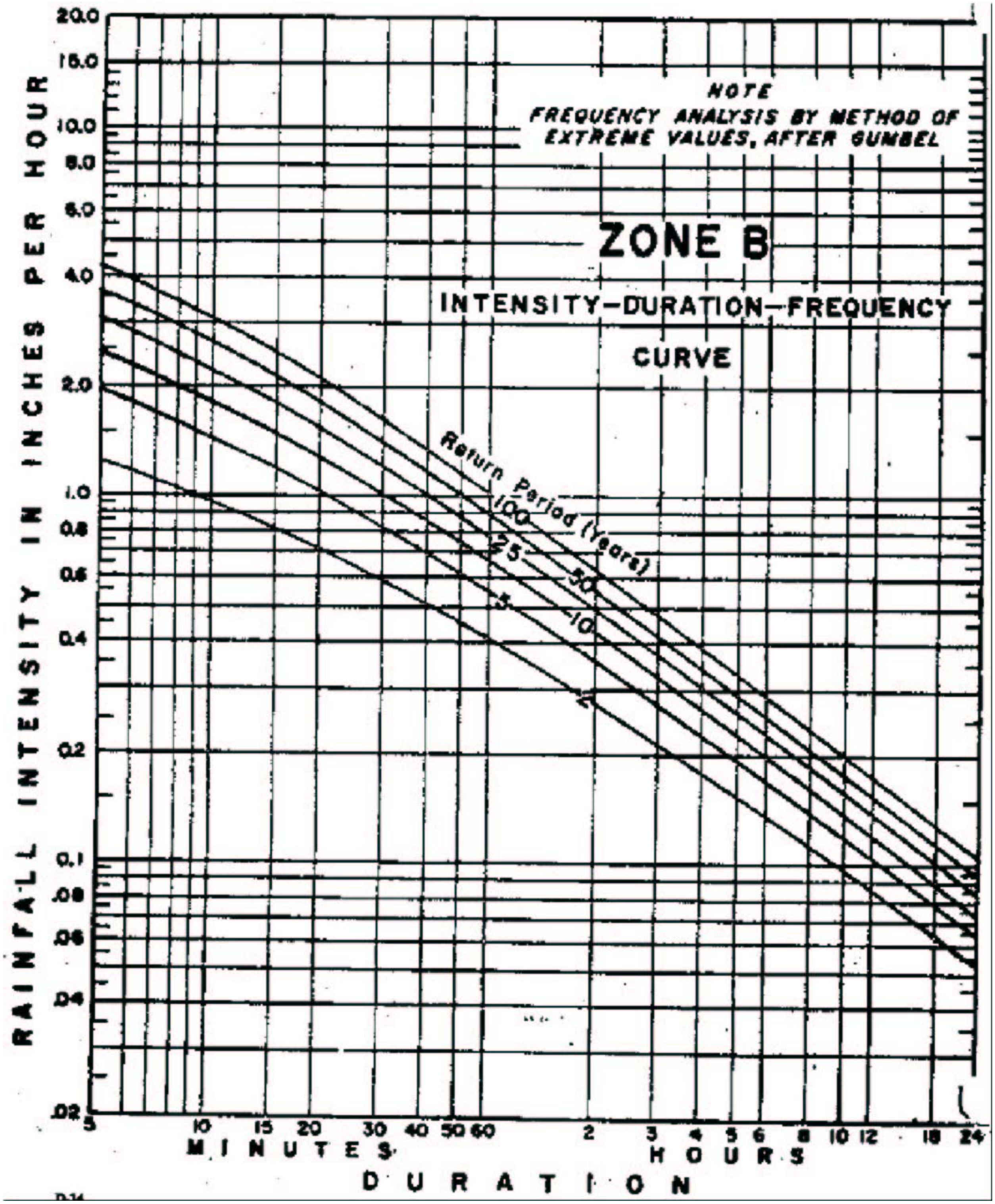


Figure B-8
Page 3 of 9

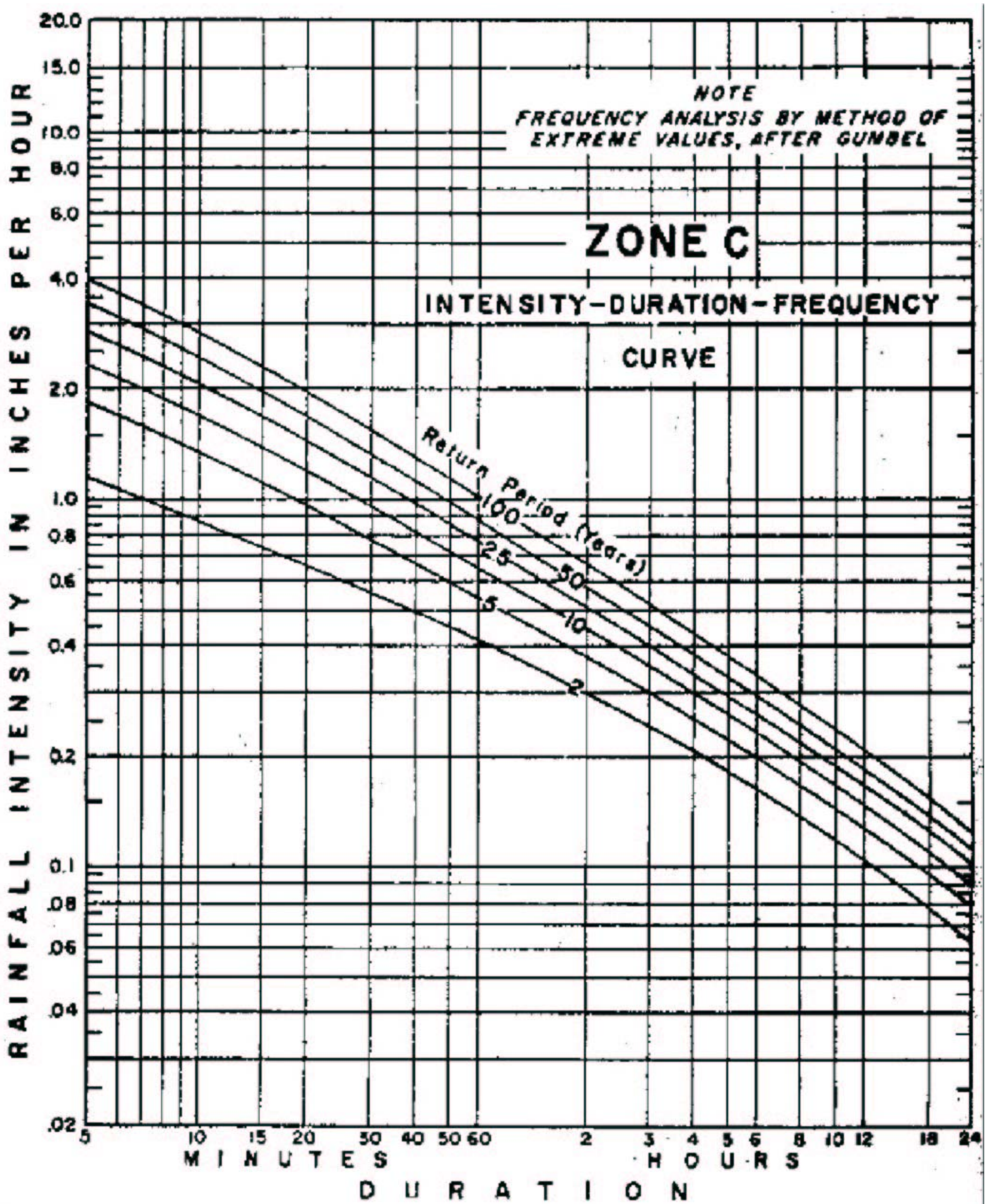


Figure B-8
Page 4 of 9

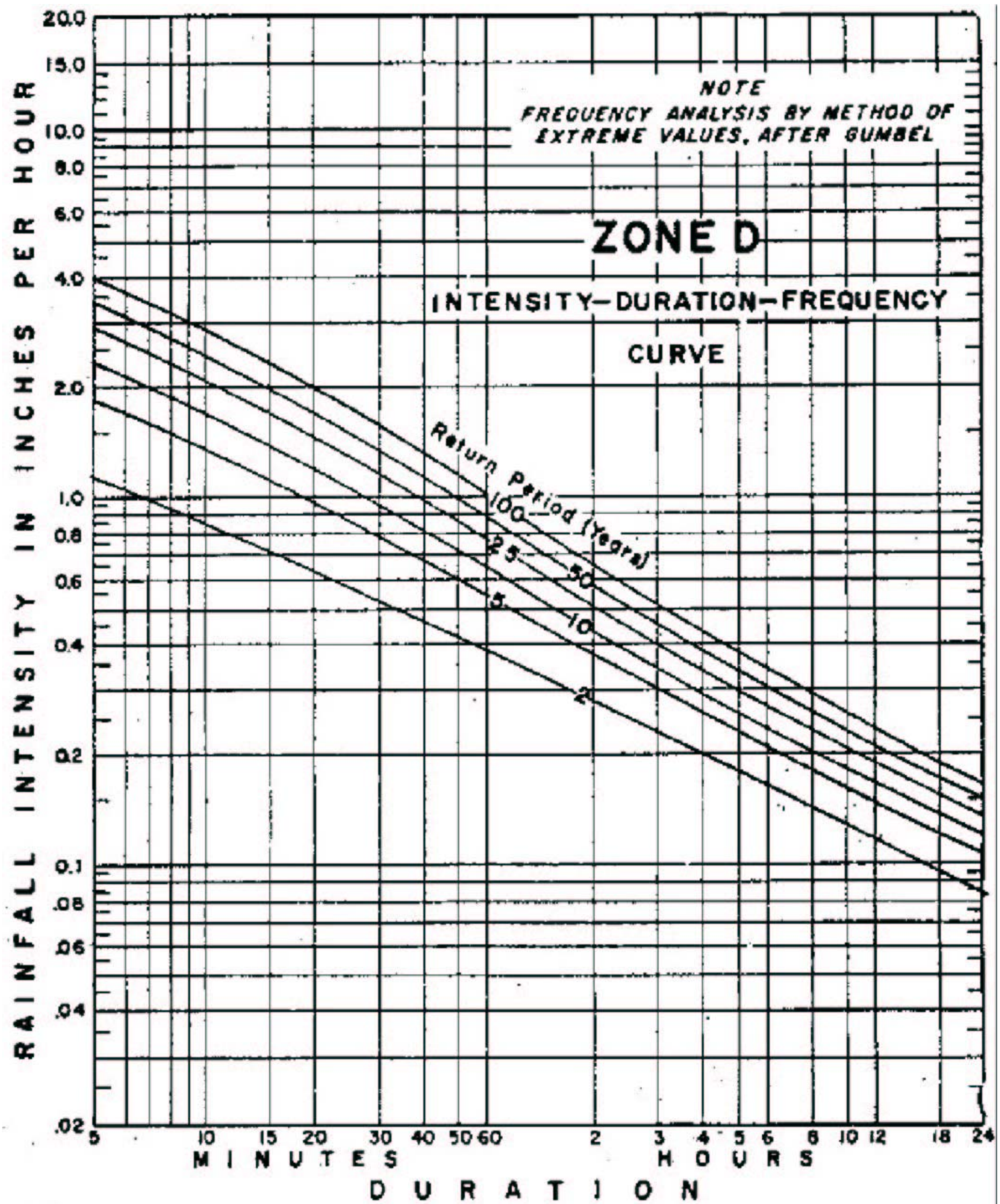
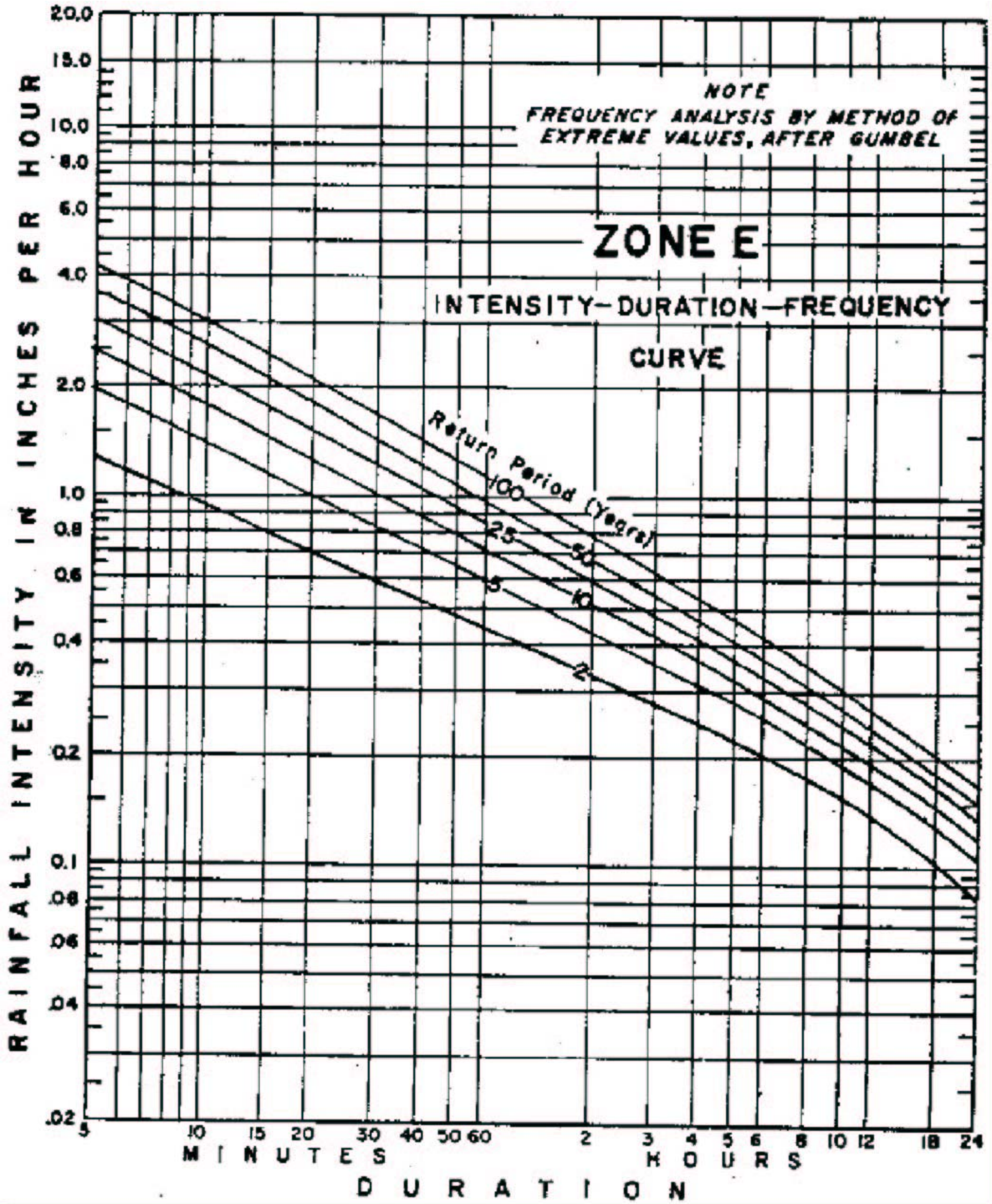
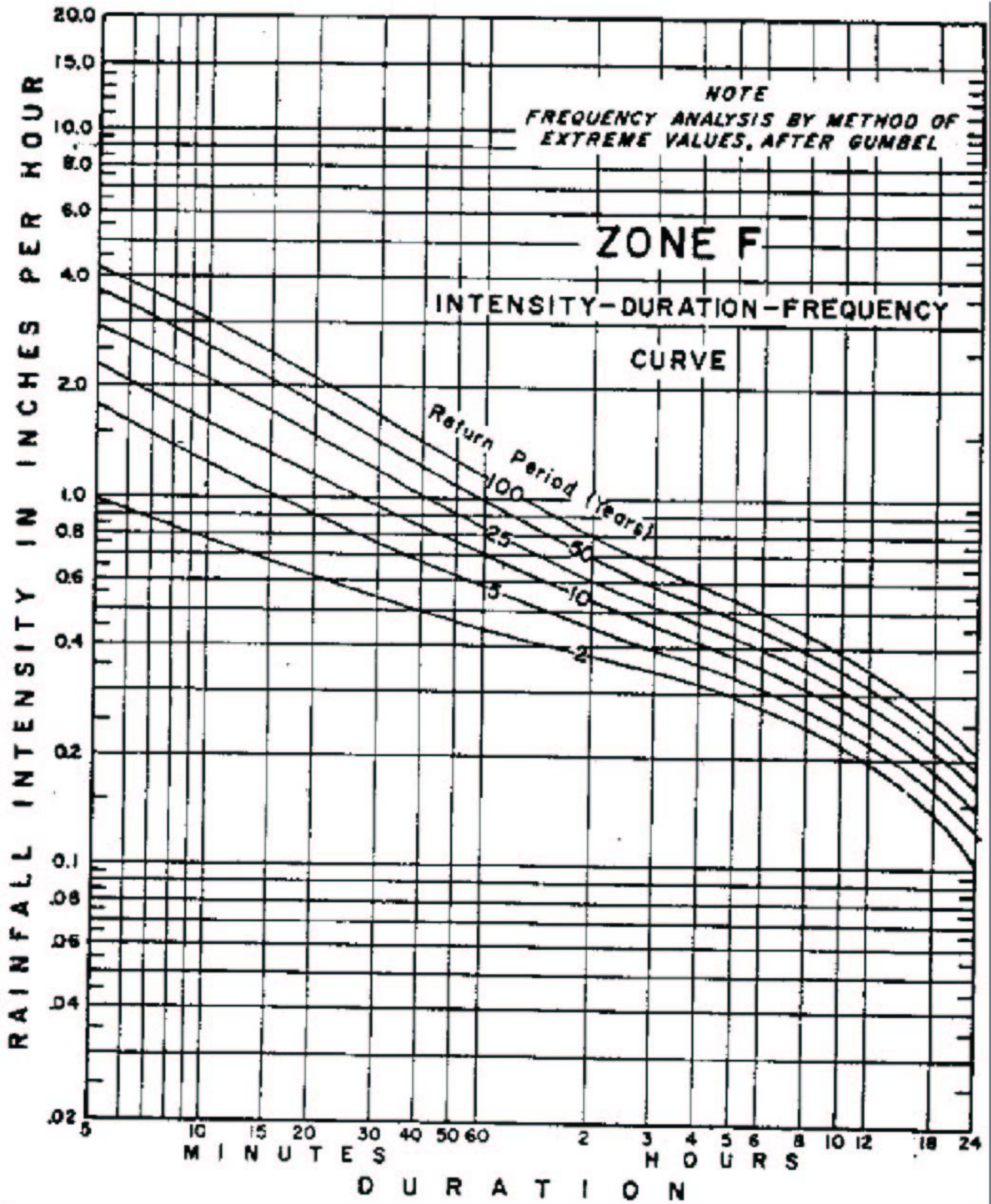


Figure B-8
Figure 5 of 9




NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE F
INTENSITY-DURATION-FREQUENCY CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50 60
MINUTES
2
3
4
5
6
8
10
12
18
24
HOURS
DURATION

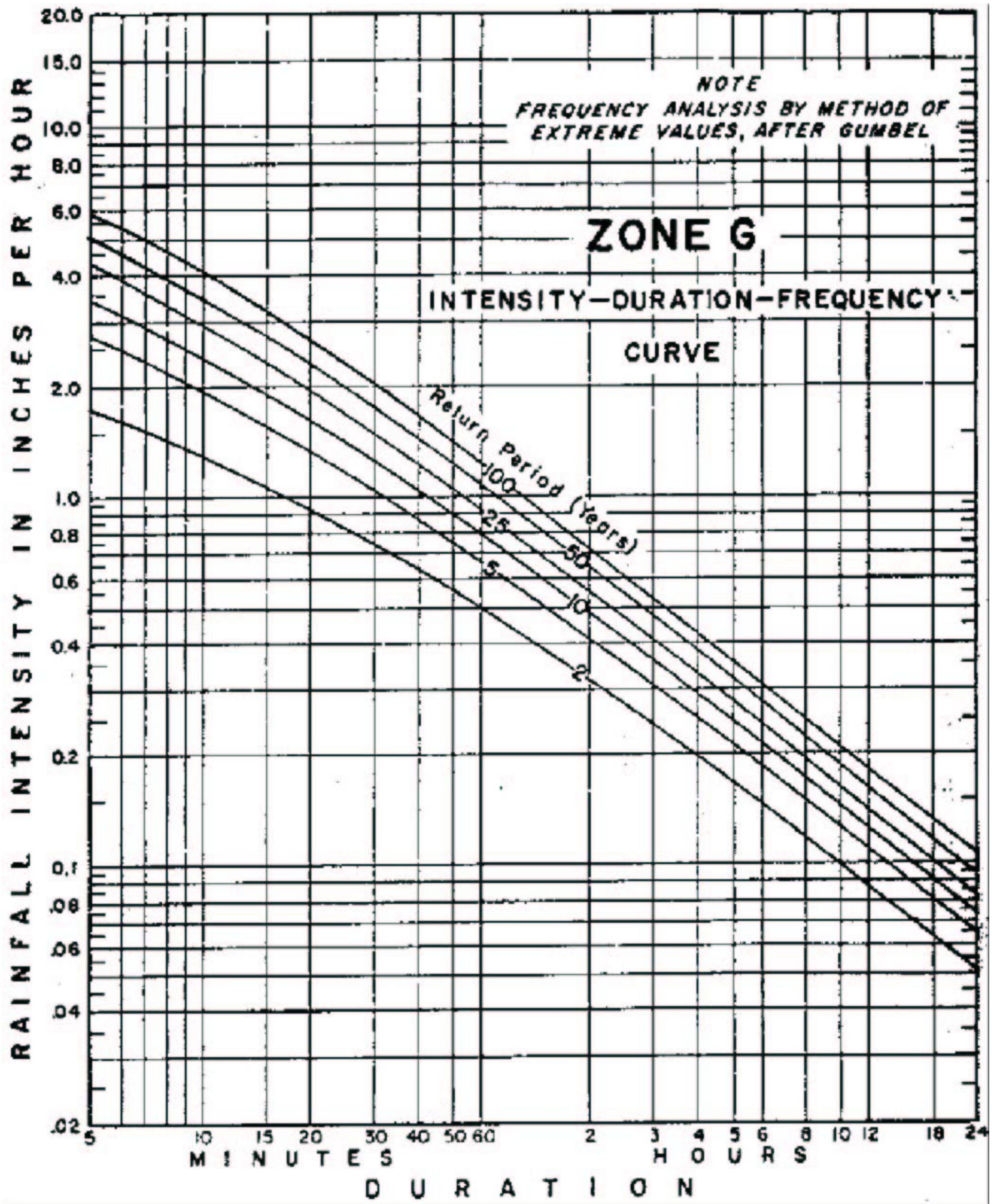

NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE G
INTENSITY—DURATION—FREQUENCY CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50
60
2
3
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION

Figure B-8
Figure 8 of 9

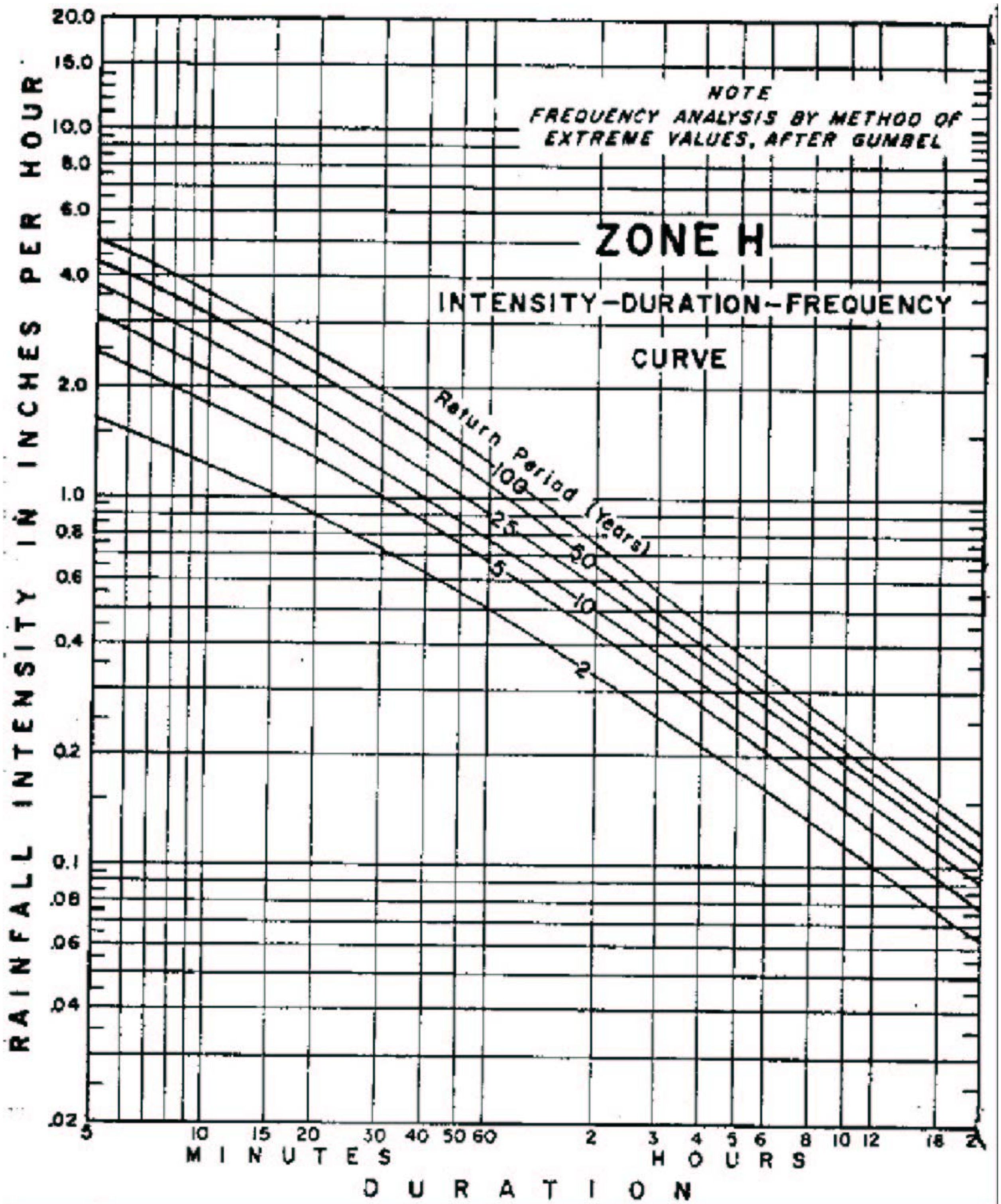
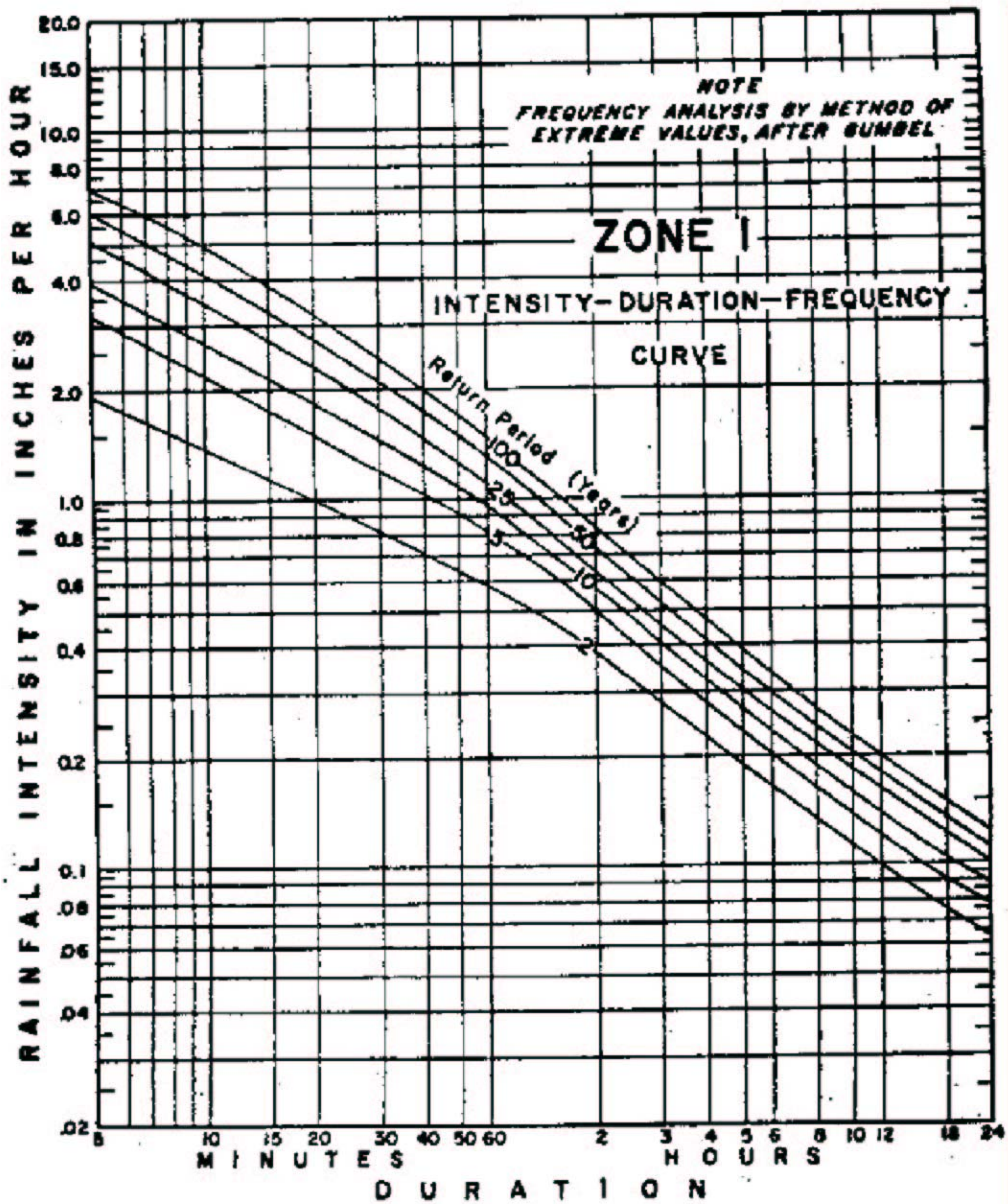


Figure B-8
Page 9 of 9



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B.40 – REGIONAL REGRESSION METHODS

Four technical reports are summarized.

B.40.01 Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho; Water-Resource Investigations 02-4170.

B.40.02 Magnitude and Frequency of Floods in Small Drainage Basins in Idaho by U.S. Geological Survey; Water-Resource Investigations 7-73. The following is a portion of this report. The report was modified for ITD projects with forest cover between 0 and 30 percent. It was discovered that abnormally high results were obtained for watersheds with a low percentage of forest cover. Details are shown in Table B-1. The revision was reviewed and concurred with by L. C. Kjelstrom and W. A. Harenberg of the U.S. Geological Survey. Minor changes have been made in the text for consistency.

A design method to determine the magnitude and frequency of floods in small drainage basins in Idaho has been compiled by the U.S. Department of the Interior, Geological Survey, in coopera¬tion with the Idaho Transportation Department, Idaho Department of Water Administration, and the U.S. Forest Service.

Authors and compilers of this report are C. A. Thomas, W. A. Harenberg, and J. M. Anderson.

Introduction to Flood Design Method

This report describes a method for estimating peak discharges at 10-, 25-, and 50-year recurrence intervals for most small streams in Idaho. Reliable estimates can be obtained using this method, but there are significant limitations and variations that should be considered.

The method of estimating peak discharges developed for this report is for sites on streams with natural flow. Therefore, for sites on regulated streams, the effect of the regulation must be superimposed on results obtained from the method described herein. Regulation may be caused either by works of man or by interaction with groundwater systems. Estimates of peak discharge may be poor for streams draining basins on or flowing across extensive areas of deep, coarse alluvium, or lava flows; for streams whose basins are urbanized; for streams draining irrigated agricultural lands; and for streams draining basins having less than about 30 percent forest cover. Computed flows in those parts of the state subject to recurrent high-intensity thunderstorms over small areas may be too low to be acceptable as reasonable estimates. Some anomalous areas have been identified where the method developed does not apply. A determination of peak discharge should not be considered complete until an assessment of the limitation has been made.

Table B-1

SUMMARY OF REGRESSION EQUATIONS BY REGION FOR PEAK DISCHARGES IN IDAHO

Region	Regression Equation for Q10	Value of Exponent n	Standard Error of Estimate (percent)	Q25/Q10 Ratio	Q50/Q10 Ratio
1	$Q10 = 49.8\ A^{0.862}$		41	1.3	1.5
2	$Q10 = 66.5\ A^{0.801}$(Forest Factor)	-0.236	61	1.3	1.5
3	$Q10 = 3.81\ A^{0.875}$(Forest Factor) $N^{2.02}$	-0.216	51	1.3	1.5
4	$Q10 = 43.4\ A^{0.857}$(Forest Factor)	-0.210	62	1.4	1.8
5	$Q10 = 13.0\ A^{0.918}$		61	1.3	1.5
6	$Q10 = 188\ A^{0.873} La^{0.773}\ N^{-1.82}$		41	1.2	1.3
7	$Q10 = 20.6\ A^{0.806} W^{-1.05}$		59	1.2	1.4
8	$Q10 = 193\ A^{0.758}$(Forest Factor) $N^{-4.25}$		45	1.4	1.7

EXPLANATION:

A	=	Drainage area in square miles (0.5 – 200 mi^2).
F	=	Percentage of forest cover plus 1 percent.
La	=	Percentage of area of lakes and ponds on the basin plus 1 percent.
N	=	Latitude of centroid of basin in degrees minus 40 degrees.
W	=	Longitude of centroid of basin in degrees minus 110 degrees.

MODIFICATION FOR USE ON ITD PROJECTS

The Forest Factor, F^n, has been modified in the appropriate equations as follows:

PERCENT FOREST 0 TO 30	PERCENT FOREST 30 TO 100
Forest Factor = $\frac{(31 - F)(30^n - 32^n)}{2} + 31^n$	Forest Factor = F^n

Where

n = exponent of F in each applicable regional equation.

Design Method

Subject to the limitations outlined in the section on UNDEFINED AREAS WHERE REGRESSION RELATIONS DO NOT APPLY, peak discharges at selected recurrence intervals can be determined for small streams as follows:

1. Locate the site on the map of Figure B-9 (pages 1, 2, and 3) and determine if a gage has been operated nearby on the same stream. An explanation of the gaging-

station-numbering system used by the U.S. Geological Survey is included later and, for convenience, also on Figure B-9.

If a gage site is located nearby on the same stream and the basin characteristics above the gaged and ungaged sites are relatively homogenous, check Table B-1 for peak discharge at the desired recurrence interval at the gaged site and adjust the peak to the ungaged site on the basis of drainage area. If the stream has not been gaged nearby, inspect Figure B-9 to determine if the basin is outside the undefined areas and, if so, determine in which region the site is located.

2. By inspection of the applicable regression equation in Table B-1, determine which basin characteristics are needed. A description of the equation symbols and methods of determining the basin characteristics are shown below.

3. Determine the required basin characteristics from the best available topographic map. A U.S. Geological Survey 7-1/2-minute topographic map is suggested. Complete coverage of the state is available in the U.S. Geological Survey 1:250,000 scale map series. Determine the forest cover (F) that is needed for evaluation purposes, even though it may not appear in the equation.

4. Having determined the basin characteristics, use the regression equations from Table B-1 to compute the peak discharges at 10-, 25-, and 50-year recurrence intervals.

5. Regression equations are valid for drainage basins from 0.5 to 200 square miles.

6. Investigate further to determine if limitations apply that invalidate the use of the regression equation or if adjustments to the discharge should be made that would improve the design discharge. Check peak discharges for reasonableness by comparing with peak discharges of record for nearby streams (see examples).

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Gaging-Station-Numbering System

Each gaging station and partial-record station has been assigned a number in downstream order in accordance with the permanent numbering system used by the Geological Survey. Numbers are assigned in a downstream direction along the main stream, and stations on tributaries between main-stream stations are numbered in the order they enter the main stream. A similar order is followed on other ranks of tributaries. The complete 8-digit number, such as 13038900 includes the part number "13" plus a 6-digit station number. Only the 6-digit station number is shown in this illustration.

Summary of regression equations by region for peak discharges in Idaho.

Region	Regression equation for Q_{10}	Standard error of estimate (percent)	Q_{25}/Q_{10} ratio	Q_{50}/Q_{10} ratio
1	$Q_{10} = 49.8\ A^{0.862}$	41	1.3	1.5
2	$Q_{10} = 66.5\ A^{0.801}F^{-0.236}$	61	1.3	1.5
3	$Q_{10} = 3.81\ A^{0.875}F^{-0.216}N^{2.02}$	51	1.3	1.5
4	$Q_{10} = 43.4\ A^{0.857}F^{-0.210}$	62	1.4	1.8
5	$Q_{10} = 13.0\ A^{0.918}$	61	1.3	1.5
6	$Q_{10} = 188\ A^{0.873}La^{0.773}N^{-1.82}$	41	1.2	1.3
7	$Q_{10} = 20.6\ A^{0.806}W^{-1.05}$	59	1.2	1.4
8	$Q_{10} = 193\ A^{0.758}F^{0.222}N^{-4.25}$	45	1.4	1.7

EXPLANATION

A = Drainage area in square miles.
F = Percentage of forest cover plus 1 percent.
La = Percentage of area of lakes and ponds on the basin plus 1 percent.
N = Latitude of centroid of basin in degrees minus 40 degrees.
W = Longitude of centroid of basin in degrees minus 110 degrees.

EXPLANATION

Part 13
River basin boundary and number

Region boundary

4
Region number

Boundary of undefined area (hatched area)

Known gaining stream reach

Known losing stream reach

Irrigated area

Gaging stations

128900
Active station and number

303000
Discontinued station and number

317200
Active crest-stage station and number

312000
Discontinued crest-stage station and number

172666
Active station and number operated by Agricultural Research Service

Parts and numbers are those permanently assigned in Geological Survey system and used in this report.

FIGURE 1.--MAP OF IDAHO SHOWING LOCATIONS OF GAGING STATIONS USED IN THE ANALYSES, REGIONS, AND SOME AREAS AND STREAMS FOR WHICH REGRESSION EQUATIONS DO NOT APPLY.

DRAINAGE AREAS, FLOOD DISCHARGES AT SELECTED FREQUENCIES, AND MAXIMUM FLOWS OF RECORD FOR STREAMS DRAINING LESS THAN 50 SQUARE MILES WITH 8 YEARS OR MORE OF RECORD

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
	Missouri River Basin								
06011900	Red Rock River Trib.	1.0	4.2	8.7	15	21	-	-	15
	Bear River Basin								
10040000	Thomas Fork	45.3	147	262	337	-	505	-	418
10040500	Salt Creek	37.6	169	294	377	-	476	-	382
10043350	Sheep Cr. Trib. No. 2	.34	3.2	6.1	8.3	11	-	-	5.4
10047500	Montpelier Creek	50.9	105	155	186	-	222	253	224
10058600	Bloomington Creek	24.4	140	187	215	245	-	-	222
10072800	Eightmile Creek	23.3	98	128	145	157	-	-	144
10090800	Battle Creek Trib.	4.5	43	81	104	121	-	-	98
10093000	Cub River	19.4	564	657	705	-	753	-	715
10099000	High Creek	16.2	204	231	245	250	-	-	250
10125000	Deep Creek	30.1	59	102	136	-	178	-	172
	Tributaries Between Great Salt Lake Desert and Bear River								
10172930	Right Hand Fk. Dove Cr.	12.2	4.1	13	25	40	-	-	32
10172940	Dove Creek	33.2	7.5	30	72	-	170	-	275
10172960	West Fork Tenmile Cr.	5.93	83	210	380	700	-	-	460
10172970	Rock Creek	44.0	167	437	741	1,100	-	-	1,390

Station No.	Station Name	Drainage	Discharge (cfs)

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Kootenai River Basin									
12304250	Whitetail Creek	2.61	27	42	53	64	-	-	49
12304300	Cyclone Creek	5.66	127	163	190	216	-	-	220
12304400	Fourth of July Creek	7.70	197	233	242	280	-	-	258
12310800	Trail Creek	16.1	175	284	390	520	-	-	341
12316800	Mission Creek	23.0	333	470	560	-	660	-	528
Pend 'Oreille River Basin									
12345800	Camas Creek	6.01	149	230	280	-	360	-	265
12347500	Blodgett Creek	26.4	637	753	814	-	880	-	836
12350200	Gash Creek	3.37	107	157	195	-	250	-	200
12350500	Kootenai Creek	28.9	830	1,100	1,330	-	1,400	-	1,300
12353800	Thompson Creek	12.2	60	101	132	165	-	-	190
12353850	East Fork Timber Cr.	2.72	35	52	65	78	-	-	66
12354100	N. Fk. Little Joe Cr.	14.7	190	210	220	225	-	-	212
12392100	Trapper Creek	1.12	34	47	56	65	-	-	52
12392800	Hornby Creek	2.2	37	44	48	56	-	-	48
12393600	Binarch Creek	10.7	64	104	132	160	-	-	117
12394300	Benton Creek	1.48	13	18	20	-	24	27	22.5

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years)						Maximum of Record
			2	5	10	20	25	50	
Spokane River Basin									
12413100	Boulder Creek	3.13	97	130	150	173	-	-	144
12413200	Montgomery Creek	4.53	75	132	178	230	-	-	155
12415100	Cherry Creek	7.07	97	168	222	280	-	-	247
12415200	Plummer Creek Trib.	2.10	57	92	120	155	-	-	122
12416000	Hayden Creek	22.0	377	620	800	-	1,050	-	790
12423550	Hangman Creek Trib.	2.18	40	117	184	250	-	-	155
12423700	S. Fk. Rock Cr. Trib.	.59	27	34	39	43	-	-	41
12423900	Stevens Creek Trib.	2.02	22	44	68	-	117	-	125
12429600	Deer Creek	31.9	136	250	360	490	-	-	391
12430370	Bigelow Gulch	2.07	19	61	120	260	-	-	1,510
Tributaries to Snake River above Henrys Fork									
13027200	Bear Canyon	3.30	45	84	112	140	-		
13030000	Indian Creek	36.8	204	267	306	-	3		
Henrys Fork Basin									
13038900	Targhee Creek	20.8	235	300	335	370	-	-	340
13050700	Mail Cabin Creek	3.27	36	50	61	77	-	-	81
13050800	Moose Creek	21.4	285	360	410	450	-	-	390
13054400	Milk Creek	17.9	98	400	833	1,500	-	-	1,350

		Area (square miles)	Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Tributaries to Snake River between Henrys Fork and Blackfoot River									
13057600	Homer Creek	26.4	220	410	550	700	-	-	448
13061100	Snake River Trib.	7.64	58	175	322	510	-	-	450
Blackfoot River Basin									
13062700	Angus Creek	13.9	188	272	334	400	-	-	375
13063500	Little Blackfoot River	38.8	140	209	275	-	318	-	292
Portneuf River Basin									
13073700	Robbers Roost Creek	5.70	14	21	26	29	-	-	24
13074000	Birch Creek	6.56	24	35	56	-	94	-	95
13075300	East Fork Mink Creek	14.7	28	45	54	63	-	-	49
13075600	N. Fk. Pocatello Cr.	14.0	23	42	58	76	-	-	57
13075700	S. Fk. Pocatello Cr.	4.3	2.3	5.0	8.0	13	-	-	9
Raft River Basin									
13077700	George Creek	7.84	67	102	124	150	-	-	146
13079000	Clear Creek	20.2	120	185	225	-	375	490	386
13079800	Heglar Canyon Trib.	7.72	185	360	580	900	-	-	1,930
Bruneau River Basin									
13152500	Columbet Creek	3.37	15	27	35	44	-	-	35
13170100	Sugar Creek Trib.	3.04	28	56	78	105	-	-	105

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Tributaries to Snake River between Bruneau River and Boise River									
13172200	Fossil Creek	19.7	22	135	175	240	-	-	195
13172668	ARS, W-13	.16	3.6	6.6	8.8	11	-	-	5.9
13172735	ARS, W-2	14.0	87	279	524	900	-	-	1,007
13172800	Little Squaw Cr. Trib.	1.81	12	44	75	115	-	-	93
Boise River Basin									
13184200	Roaring River	23.3	370	500	580	660	-	-	575
13184800	Beaver Creek	9.3	103	149	181	218	-	-	195
13185500	Cottonwood Creek	20.9	74	190	310	475	-	-	166
13196500	Bannock Creek	5.75	12	23	32	-	45	-	46
13200500	Robie Creek	15.8	59	106	160	-	255	-	274
13207000	Spring Valley Creek	20.9	50	129	206	-	336	-	244
13210300	Bryans Run	7.94	68	180	290	430	-	-	420

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Payette River Basin									
13234300	Fivemile Creek	7.8	158	214	247	280	-	-	290
13235100	Rock Creek	14.6	144	275	390	530	-	-	400
13237300	Danskin Creek	10.1	36	60	76	94	-	-	71
13237600	Cabin Creek	.42	3.2	7.8	12	17	-	-	18
1323700	Control Creek	.59	3.8	11	18	27	-	-	6.6
13238300	Deep Creek	4.38	337	430	499	620	-	-	540
13240000	Lake Fork Payette R.	48.9	1,380	1,750	1,980	-	2,260	2,460	2,600
13245400	Tripod Creek	8.63	80	118	144	175	-	-	183
13248900	Cottonwood Creek	6.53	80	142	220	300	-	-	303
13250600	Big Willow Creek	47.4	890	1,600	2,140	2,700	-	-	2,100
13250650	Fourmile Creek	6.5	120	320	510	760	-	-	500
13250700	Langley Gulch	3.88	0	3.3	32	62	-	-	39
Weiser River Basin									
13251300	West Branch Weiser R.	3.96	34	53	76	103	-	-	84
13251500	Weiser River	36.5	460	660	790	-	1,020	1,200	1,320
13252500	East Fk. Weiser River	2.0	53	70	80	91	-	-	77
13257500	Johnson Creek	4.81	132	179	211	248	-	-	222
13267100	Deer Creek	4.6	67	112	140	170	-	-	156

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Tributaries to Snake River between Weiser River and Salmon River									
13289600	East Brownlee Creek	7.97	78	190	290	420	-	-	325
Salmon River Basin									
13292400	Beaver Creek	15.0	138	176	200	230	-	-	225
13293000	Alturas Lake Creek	35.7	475	610	680	-	785	-	633
13297100	Peach Creek	7.62	26	62	95	136	-	-	105
13298300	Malm Gulch	9.38	85	300	471	600	-	-	440
13301700	Morse Creek	18.0	132	200	245	290	-	-	230
13301800	Morse Creek	19.9	18	70	105	246	-	-	90
13302200	Twelvemile Creek	22.0	41	61	75	89	-	-	70
13305700	Dahlonega Creek	32.0	95	162	216	273	-	-	235
13305800	Hughes Creek	15.7	146	193	218	240	-	-	220
13311000	E. Fk. S. Fk. Salmon R.	19.5	177	252	298	-	358	-	369
13311500	E. Fk. S. Fk. Salmon R.	42.5	340	510	620	-	780	-	783
13313800	Tailholt Creek	2.46	7.7	13	20	-	33	-	27
13315500	Mud Creek	15.8	200	290	350	-	435	510	395
13316000	Boulder Creek	5.84	160	220	265	307	-	-	244
13316800	N. Fk. Skookumchuck Cr.	15.3	130	240	360	-	580	-	471
13317200	Johns Creek	6.67	96	240	380	580	-	-	400

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Tributaries to Snake River between Salmon River and Clearwater River									
13335200	Critchfield Draw	1.8	19	245	500	-	1,300	-	705
Clearwater River Basin									
13336600	Swiftwater Creek	6.19	83	114	133	145	-	-	150
13336650	E. Fk. Papoose Creek	4.51	77	114	135	147	-	-	125
13336850	Weir Creek	12.2	270	440	550	660	-	-	470
13337200	Red Horse Creek	9.13	92	141	185	220	-	-	200
13337700	Peasley Creek	14.2	79	120	158	220	-	-	240
13338200	Sally Ann Creek	13.9	191	251	284	320	-	-	305
13339700	Canal Gulch Creek	5.9	112	167	210	270	-	-	291
13339900	Deer Creek	6.8	79	215	350	550	-	-	485
13341100	Cold Springs Creek	8.25	59	140	215	310	-	-	200
13341300	Bloom Creek	3.15	51	94	133	175	-	-	151
13341400	E. Fk. Potlatch River	41.6	610	936	1,200	1,580	-	-	1,740
Palouse River Basin									
13344700	Deep Creek Trib.	2.90	54	82	104	130	-	-	157
13344800	Deep Creek	36.6	799	1,220	1,480	1,730	-	-	1,700
13346300	Crumarine Creek	2.41	13	19	24	28	-	-	24
13348400	Missouri Flat Cr. Trib.	.88	30	90	190	-	430	-	234
13348500	Missouri Flat Creek	27.1	315	520	940	-	1,600	-	1,500

Basin Characteristics

Descriptions and methods of determination of the five basin characteristics used in the regression equations are given below.

1. Drainage Area (A)

   Drainage area is in square miles and is determined by outlining on the best available topographic map the surface water divide upstream from the point of interest on the stream and determining the area from the map using a planimeter. U.S. Geological Survey 7-1/2 or 15-minute quadrangle maps are recommended when available.

2. Forest Cover (F)

   Forest cover is expressed as the percentage plus 1 percent of the drainage area covered by forests and is determined from a U.S. Geological Survey 1:250,000 scale map. A recom¬mended procedure is to lay a grid over the basin outline, count the number of grid intersections lying within the forested (green) areas and the number of grid intersections within unforested areas and, from this, calculate the percentage of the basin that is forested.

3. Areas of Lakes and Ponds (La)

   Areas of lakes and ponds are expressed as the percentage plus 1 percent of the drainage area covered by water (lakes, ponds, or swamps) and is determined by the grid method. See forest cover (F) above. U.S. Geological Survey 7-1/2 or 15-minute quadrangle maps are recommended when available.

4. Latitude (N)

   Latitude is the latitude of the centroid of the basin in decimal degrees minus 40 degrees. It is determined from inspection of the basin as outlined on a U.S. Geological Survey 1:250,000 scale map.

5. Longitude (W)

   Longitude is the longitude of the centroid of the basin in decimal degrees minus 110 degrees. It is determined from inspection of the basin as outlined on a U.S. Geological Survey 1:250,000 scale map.

Relative Magnitude of Floods

Comparison of estimates of floods at ungaged sites with the maximum floods known is useful in evaluating the relative magnitude and to ascertain the credibility of the estimates. The maximum known flood is often used as the design flood. Relative magnitude of floods is desirable for use in both planning and design.

The maximum discharges of record for streams in Idaho that are significant for comparative purposes are plotted against drainage areas in Figure B-10. The plot includes significant maximum discharges at miscellaneous sites as well as at short-term gaging stations. The plot also shows the wide range of peak discharges that have been recorded. Peak discharges, as computed by the outlined method, should be checked for credibility by plotting on the graph and comparing with the flows experienced at nearby stations. Only the stations with maximums of record greater than 100 cfs/mi2 have been identified by station number. A specific site in Tables B-2 and B-3 can be identified on the graph using the drainage area and maximum discharge from the figures.

For comparative purposes, three curves are shown in Figure B-10: The Matthai curve (Matthai, 1969, p. B6) is an average through the highest known floods recorded in the United States up to 1965; the Hoyt and Langbein curve (Matthai, 1969, p. B6) is an average through the maximum floods recorded prior to 1950; and the Creager, Justin, and Hinds curve (Matthai, 1969, p. B6) is an average through the maximum known flood data available in 1890. Concerning the increase between the 1890 and 1950 curves, Hoyt and Langbein (Matthai, 1969, p. B6) stated: "This is no evidence that flood conditions are changing. The upward shift of the curves is due entirely to an increased number of gaging stations and increased period of record."

As more records become available, the upper limits of the maximum known flood plot will move upward as additional rare floods are measured. Nevertheless, Figure B-10 is indicative of what can be expected in the future.

Generalizations regarding magnitude and frequency of floods in Idaho can be made from Figure B-10. Floods greater than about 300 cfsm have rarely been observed on basins greater than 4 square miles. Most floods having rates greater than 300 cfsm occur in unforested basins, a few of which have been denuded by range fires. This large a flow has been recorded at only one site on a forested basin, Canyon Creek tributary near Lowman (M13234215), and there the forest cover was light.

All floods greater than 300 cfsm were from intense thunderstorms and were unassociated with snowmelt. All basins with floods greater than 100 cfsm have drainage areas less than 40 square miles, and only five of these floods were not caused by intense thunderstorms. Conversely, a flood greater than 100 cfsm has not yet been recorded in Idaho on a basin larger than about 400 square miles. Evidently, floods that plot to the left of any of the three curves in Figure B-10 have long recurrence intervals and are rare.

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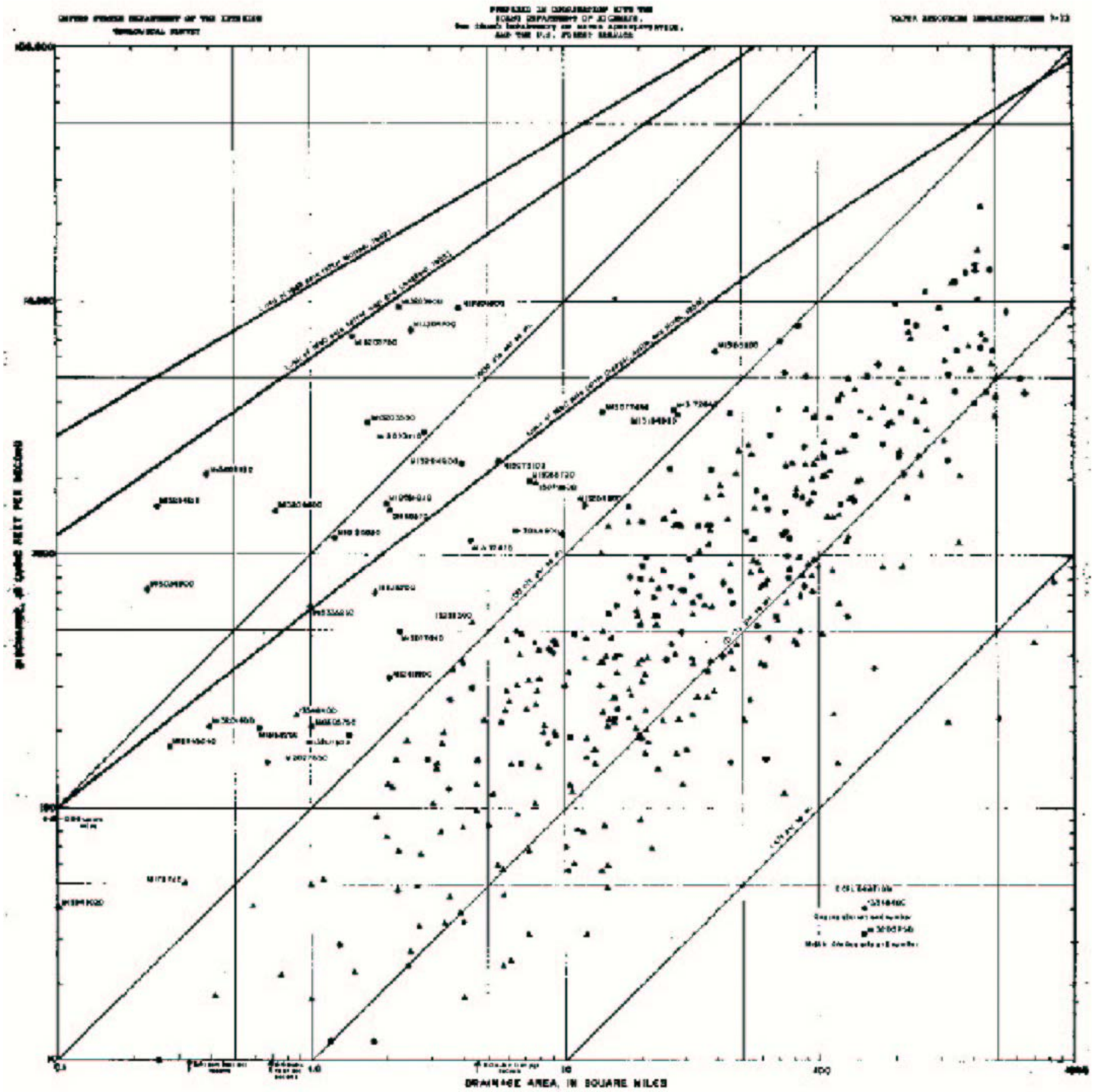
Figure B-10



MAXIMUM DISCHARGES IN RELATION TO DRAINAGE AREA.

Table B-3

MAXIMUM DISCHARGES AT SELECTED SITES

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Bear River Basin			
10041000	Thomas Fork near Wyoming-Idaho State Line	113	05-18-50	869
10047000	Montpelier Creek near Montpelier	28.2	04-24-43	224
10071500	Skinner Creek near Nounan	5.41	06-08-44	60
10087500	Mink Creek below Dry Fork	19.3	05-29-48	600
M10091030	Battle Creek Tributary No. 2	a2	08-21-61	1,600
10119000	Little Malad River	120	02-10-62	1,450
M10120030	Little Danish Canyon	1.25	08-25-61	1,170
10091200	Deep Creek near Clifton	119	03-31-69	152
10120500	Little Malad River	223	02-11-62	1,720
M10122550	Devil Creek	15	02-01-63	585
M10172966	Deep Creek	a72	02-11-62	1,220
	Tributaries to Great Basin between Great Salt Lake Desert and Bear River			
M10172973	Rock Creek	93	02-10-62	1,630
M10172974	Wood Canyon	a1.3	02-10-62	29
	Kootenai River Basin			
12305500	Boulder Creek	53	05-30-69	2,720
12309000	Cow Creek near Bonners Ferry	14.7	06-09-33	60
12311000	Deep Creek at Moravia	133	05-18-54	1,670
12311500	Snow Creek near Moravia	19.5	06-14-33	572
12312000	Caribou Creek near Moravia	14.0	06-15-33	376
12313000	Myrtle Creek near Bonners Ferry	a37	06-05-33	1,260
12313500	Ball Creek near Bonners Ferry	a27	06-15-33	644
12315200	Rock Creek near Copeland	14.3	04-26-23	86
12315400	Trout Creek near Copeland	a20	06-16-33	533
12317000	Mission Creek at Copeland	a31	05-22-32	370
12317500	Brush Creek near Copeland	a7.2	04-26-33	68
12319500	Parker Creek near Copeland	16.5	06-15-33	400
12320500	Long Canyon Creek near Porthill	a29	05-27-48	1,300
12321000	Smith Creek near Porthill	a70	06-23-55	3,810
12321500	Boundary Creek near Porthill	a97	06-23-55	3,280

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Pend 'Oreille River Basin			
M12392120	East Fork Creek	20.4	06-08-64	903
M12392150	Lightning Creek	90	05-27-48b	5,100
12392300	Pack River	124	05-30-69	4,370
12392400	Rapid Lightning Creek	45	04-20-65	718
M12392950	Indian Creek	20	05-27-48b	800
	Spokane River Basin			
M12411800	East Fork Eagle Creek	9.13	06-08-64	457
M12411900	Cottonwood Creek	2.05	06-08-64	328
M12413120	Canyon Creek	18.1	06-08-64	817
12413140	Placer Creek at Wallace	14.9	12-23-64	a1,300
12413700	Latour Creek near Cataldo	24.8	02-19-68	1,400
M12413450	Pine Creek	74.0	12-23-64	5,290
M12413470	South Fork Coeur d'Alene River	310	02-21-61	9,440
M12413900	St. Joe River	472	05-29-48	13,400
M12413950	North Fork St. Joe River	111	05-28-48	3,500
12415000	St. Maries River	437	12-22-33	23,800
	Salt River Basin			
13025500	Crow Creek near Fairview, WY	114	04-19-46	236
13026000	Stump Creek near Auburn, WY	103	05-18-48	490
	Tributaries to Snake River between Salt River and Henrys Fork			
M13034900	Snake River Tributary No. 7	.23	06-01-63	729
13035500	Pine Creek near Swan Valley	63.2	05-16-36	799
M13037600	Birch Creek	21	02-11-62	980
M13038410	Lyons Creek	a18	02-11-62b	1,560
	Henrys Fork Basin			
13041500	Sheridan Creek near Island Park	82.1	05-31-38	447
13047800	N. Fk. Squirrel Cr. near Squirrel	2.40	05-16-64	184
13051000	Trail Creek near Victor	47.6	06-07-52	445
13051500	Teton Creek near Driggs	33.8	06-06-52	1,030
13052500	Horseshoe Creek near Driggs	11.7	05-03-52	81
13053000	Packsaddle Creek near Tetonia	5.7	05-19-49	58
M13054600	Canyon Creek	a76	02-11-62b	814
M13-55320	Moody Creek	a88	02-11-62b	2,700

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Willow Creek Basin			
13058000	Willow Creek	622	02-11-62	5,080
	Tributaries to Snake River between Shelley and Blackfoot			
M13059100	Snake River Tributary No. 5	5.2	02-11-62	114
M13059200	Snake River Tributary No. 4	3.55	02-11-62	270
M13059300	Snake River Tributary No. 3a	3.5	02-11-62	120
M13059400	Snake River Tributary No. 3	16	02-11-62	632
M13062600	Snake River Tributary No. 6	63.5	02-11-62	1,540
	Blackfoot River Basin			
M13066600	Sand Creek Tributary	a9.8	02-11-62	1,210
M13066700	Black Canyon	7.29	08-09-63	1,940
M13066800	Henrys Creek	a29	02-11-62	716
M13066900	Cedar Creek	10.5	02-11-62	194
	Portneuf River Basin			
13071500	Topons Creek near Chesterfield	45.7	05-21-12	355
M13072100	Portneuf River Tributary	a130	02-01-63	574
M13072300	Portneuf River	332	02-11-62b	2,380
M13072750	Fish Creek	20.1	02-01-63	1,360
M13072900	Dempsey Creek	42	02-01-63	400
M13073100	Jenkins Canyon	5.50	08-01-60	2,350
M13073710	Green Canyon Tributary	2.82	08-12-61	3,060
M13073720	Portneuf River	650	02-13-62	4,380
M13073750	Marsh Creek	a68	02-12-62	573
13074000	Birch Creek near Downey	6.56	07-15-38	95
M13075100	Rapid Creek	57.2	02-01-63	526
M13075400	Gibson Jack Creek	10.3	02-12-62	57
	Bannock Creek Basin			
13076000	Bannock Creek	227	12-24-64	7,790
M13076100	Rattlesnake Creek	a77	02-11-62b	1,170
M13076200	Bannock Creek	413	02-11-62	4,010
	Rock Creek Basin			
M13077100	Trail Creek	a11	09-09-61	487
M13077200	Rock Creek	96	02-11-62	1,770
M13077400	Rock Creek	156	02-01-63	5,100
M13077550	Rock Creek	216	02-11-62	2,120

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Rock Creek Basin (continued)			
M13077630	Spring Canyon Tributary	6.77	08-18-61	152
M13077640	Rocky Hollow Tributary	2.26	05-30-63	498
M13077650	Rock Creek	320	12-23-64	7,950
	Tributaries to Snake River between Rock Creek and Raft River			
M13077652	Dairy Canyon	26.2	01-17-71	750
M13077655	Fall Creek	14.2	07-10-70	3,700
	Raft River Basin			
13079070	Meadow Creek near Sublett	37.7	05-09-71	626
13079100	Cassia Creek above Stinson Creek	7.2	06-24-69	32
13079200	Cassia Creek near Elba	a84	12-23-64	982
M13079750	Heglar Canyon	a45	02-11-62	153
M13079820	Heglar Canyon	62.0	01-17-71	471
M13079890	Calder Creek	23.6	01-17-71	735
	Tributaries to Snake River between Raft River and Big Wood River			
13082300	Marsh Creek near Albion	a86	01-17-71	828
13083000	Trapper Creek near Oakley	53.7	08-17-41	270
M13084800c	"D" Drain Tributary	5.0	12-23-64	86
M13084900c	"F" Drain	64.7	12-23-64	2,990
13088500	Big Cottonwood Creek near Oakley	a29	05-30-12	125
13092000	Rock Creek near Rock Creek	a80	05-19-70	461
13108500	Camas Creek at Eighteenmile Shearing Corral	a210	05-08-69	2,590
13113000	Beaver Creek at Spencer	a120	04-24-69	642
13114000	Beaver Creek at Camas	510	04-21-62	229
13116000	Medicine Lodge Creek	165	04-15-62	361
13117000	Birch Creek near Reno	320	04-01-62	220
13117300	Sawmill Creek near Goldburg	74.3	06-12-65	651
13119000	Little Lost River near Howe	703	08-11-36	450
13120000	N. Fk. Big Lost R. at Wild Horse	114	06-12-65	1,420
13129800	Alder Creek below South Fork	27.6	05-24-67	165
13130900	Antelope Creek above Willow Creek	93.4	05-24-67	829
M13132540	Big Lost Tributary	a20	02-11-62	190
M13132555	Big Lost River Tributary No. 2	a8.7	02-11-62	424
	Big Wood River Basin			
13135500	Big Wood River near Ketchum	137	05-24-67	1,690
13136500	Warm Springs Creek at Guyer Hot Springs	a96	05-21-58	961
M13142850	Big Wood River Tributary	15.8	02-12-62	226
M13145800	Thorn Creek	a46	02-11-62	647
M13145900	Preacher Creek	a26	12-23-64	2,210
M13147100	Dry Creek	a84	12-22-64d	8,050
13150500	Silver Creek	a88	02-04-63	757
	Clover Creek Basin			
M13153800	Clover Creek	71.2	12-23-64	7,000
M13153900	Calf Creek	39.4	12-23-64	6,400
13154000	Clover Creek near Bliss	140	02-13-70	4,500
M13154400	Clover Creek	265	12-23-64	10,100

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Big Wood River Basin (continued)				
Tributaries to Snake River between Clover Creek and Bruneau River				
13155000	King Hill Creek near King Hill	78.9	02-01-63	2,320
M13155100	Rosevear Gulch	55.9	08-31-63	1,160
13155400	Little Canyon Cr. at Berry Ranch	26.9	12-23-64	1,330
13156500	Bennett Creek near Bennett	21.3	04-02-43	204
13157000	Bennett Creek near Hammett	68.6	02-16-13	550
M13161050	Squaw Creek	61.5	09-16-61	368
Bruneau River Basin				
13163200	Sheep Creek	a180	06-05-63	2,760
M13168380	Hot Creek	42.2	08/13/68	772
M13169250	Bruneau River Tributary	.63	08-13-68	208
13169500	Big Jacks Creek	253	02-21-43	2,100
13170000	Little Jacks Creek	100	01-21-43	908
M13170200	Sugar Creek	33.6	08-13-68	1,300
Tributaries to Snake River between Bruneau River and Boise River				
M13172100	Browns Creek	a31	08-13-68	967
M13172300	Sinker Creek	a74	12-23-64	1,500
M13172600	Rabbit Creek	a45	06-19-62	3,640
M13172620	Rabbit Creek Tributary	4.3	06-19-62	1,140
M13172640	West Rabbit Creek	27.0	06-20-62	3,740
M13172700	Nancy Gulch	a4	06-19-62	375
13172720	Macks Creek	12.3	01-28-65	390
13172725	Reynolds Creek Tributary	.32	06-19-69	50.7

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Tributaries to Snake River between Bruneau River and Boise River (continued)				
13172740	Reynolds Creek	90.2	12-23-64	3,800
13173500	Sucker Creek	413	02-01-63	13,300
13178000	Jordan Creek	440	12-24-64	7,530
Boise River Basin				
M13184950	Sheep Creek	28.2	12-23-64	3,590
13187000	Fall Creek	55.3	04-27-52	1,150
M13192400	Rattlesnake Creek	37.8	12-23-64	1,320
M13192900	Willow Creek	57.0	12-23-64	1,820
13198000	Elk Creek	13.1	08-17-41	172
M13201400	Sheep Creek	0.40	08-20-59	210
M13203520	Highland Valley Gulch	.39	08-20-59	2,100
M13203530	Highland Valley Gulch	1.69	08-20-59	3,370
M13203600	Maynard Gulch	2.25	08-20-59	9,540
M13203750	Squaw Creek	1.47	08-20-59	7,320
M13203800	Warm Springs Creek	3.84	08-20-59	9,390
M13204600	Orchard Gulch	.73	08-20-59	1,500
M13204700	Picket Pin Creek	2.50	08-20-59	7,720
M13204800	Cottonwood Gulch	12.0	08-20-59	1,580
M13204900	Curlew Gulch	3.95	08-20-59	2,300
M13205650	Ussery Street Gulch	.06	06-21-67	90
M13205700	Stuart Gulch	9.04	01-29-65	412
M13205750	Polecat Gulch	1.01	06-21-67	210
M13205800	Boise River Tributary	.25	06-21-67	9.8
M13205850	Pierce Gulch	1.18	06-21-67	12
M13206100	Seaman Gulch	1.76	06-21-67	12
M13207650	Goose Creek	1.42	05-20-68	195
Payette River Basin				
M13234215	Canyon Creek Tributary	a.25	07-09-68	1,550
13234500	Clear Creek	59.6	05-31-43	754
13235500	Deadwood River	10.4	06-15-52	354
13236500	Deadwood River	112	05-26-28	2,150
M13237820	Lightning Creek	24.4	12-23-64	864
M13237840	Scriver Creek	27.3	12-22-55	406

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Payette River Basin			
M13237900	Anderson Creek	34.0	12-22-55	690
13247000	Porter Creek	21.2	08-11-41	181
M13248800	Shafer Creek	74.6	12-22-55	1,240
M13249050	Cottonwood Creek	29.6	12-22-55	722
M13249100	Little Squaw Creek	75.3	12-22-55	1,000
M13249200	Squaw Creek	345	12-22-64	12,000
M13250680	Big Willow Creek	138	01-15-56	1,640
	Weiser River Basin			
13253000	East Fork Weiser River	31.6	12-22-55	821
13253500	Weiser River at Starkey	106	03-27-40	2,450
M13260100	West Fork Pine Creek	a29	12-22-55	499
13255500	Hornet Creek near Council	107	12-22-55	2,090
13257000	Middle Fork Weiser River	86.5	12-22-55	1,710
13259500	Rush Creek	32.0	03-16-38	582
13260000	Pine Creek	a54	02-25-58	850
13261000	Little Weiser River	81.9	02-24-25	a1,840
M13261600	Little Weiser River	206	12-22-55	4,800
M13261650	Weiser River	952	12-22-55	16,600
M13263700	Crane Creek	a120	12-22-55	4,120
M13263750	Hog Creek	a25	12-22-55	338
M13263800	Mill Creek	a10	12-22-55	305
M13263950	South Fork Crane Creek	a52	01-17-70	1,240
13267000	Mann Creek	a56	03-27-40	1,540
13268500	Monroe Creek	a32	02-27-40	a650

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Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Tributaries to Snake River between Weiser River and Salmon River				
M13269230	Hog Creek	22.5	01-17-70	681
M13289650	Brownlee Creek	a62	12-22-55	159
M13289900	Wildhorse Creek	a120	12-22-55	2,550
M13289950	Wildhorse Creek	a140	12-22-55	2,990
13290190	Pine Creek	a230	02-21-68	2,110
Salmon River Basin				
13292500	Salmon River	94.7	05-29-52	721
13295000	Valley Creek	147	05-24-56	2,000
13296000	Yankee Fork Salmon River	195	06-12-21	3,360
M13297200	Slate Creek	a28	08-09-63	1,580
13297300	Holman Creek	6.10	06-13-65	a25
13297450	Little Boulder Creek	18.4	06-25-71	279
13299200	Challis Creek	91.2	06-12-65	918
13302000	Pahsimeroi River	845	06-08-57	796
13306000	North Fork Salmon River	214	06-13-33	901
13308500	Middle Fork Salmon River	138	05-24-561	2,980
13309000	Bear Valley Creek	180	05-27-56	3,860
13310000	Big Creek	470	06-03-48	5,800
13310500	South Fork Salmon River	92	05-27-56	1,620
M13310700	South Fork Salmon River	324	05-28-48	5,200
13312000	East Fork South Fork Salmon River	104	06-14-33	2,050
13312500	Johnson Creek	54.7	05-27-48	1,510
13313000	Johnson Creek	213	05-27-56	5,440
M13313200	East Fork South Fork Salmon River	424	05-28-48	10,400
13313500	Secesh River	104	06-03-48	2,500
13314500	Warren Creek	37	06-03-48	1,100
M13315800	Little Salmon River	189	06-01-48	3,300
M13316200	Little Salmon River	345	12-22-55	4,480
M13316300	Indian Creek	2.66	05-20-70	34
M13316400	Rapid River	122	05-29-48	1,600
M13316450	Little Salmon River	550	06-01-48	9,200
M13316600	Slate Creek	127	06-01-48	2,600
M13317050	White Bird Creek	a96	05-22-48	3,500
13317500	Deer Creek	19.1		209

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Tributaries to Snake River between Salmon River and Clearwater River				
M13335250	Snake River Tributary No. 8	1.0	06-08-64e	622
Clearwater River Basin				
M13335420	Selway River	211	05-28-48	3,700
M13336620	White Sand Creek	244	05-29-48	8,100
M13336630	Crooked Fork	172	05-29-48	5,700
13336800	Warm Springs Creek	74.7	06-13-59	2,260
13336900	Fish Creek	89.2	05-20-64	2,280
M13337550	South Fork Clearwater River	434	05-29-48	6,600
M13338300	Cottonwood Creek	81.7	01-29-65	1,740
M13338950	Lawyer Creek	208	01-29-65	2,460
13339500	Lolo Creek	243	06-08-64	3,430
M13340200	North Fork Clearwater River	201	05-28-48b	9,900
M13340400	Kelly Creek	380	05-28-48b	13,000
M13340800	Little North Fork Clearwater River	414	05-29-48	14,000
M13341140	Big Canyon Creek	225	01-29-65	8,360
13341500	Potlatch River	424	01-29-65	16,000
M13341800	Lapwai Creek	37.9	01-29-65	2,190
13342000	Mission Creek	a16	01-29-65	a400
M13342400	Lapwai Creek	235	01-29-65	4,380
M13343020	Lindsay Creek Tributary No. 1	.10	07-16-64	40.6
M13343040	Lindsay Creek Tributary No. 2	.28	07-16-64	176
M13343060	Lindsay Creek Tributary No. 3	4.25	07-16-64	300
13345000	Palouse River	317	01-00-48	12,000

a Approximately.
b Date may have been day following that indicated.
c Flood discharge may be affected by canals, drains, or other works of man.
d Date may have been 12-24-64.
e Date may have been 07-16-64.

Example One – Application of the Design Method

Determine the 10-, 25- and 50-year floods for Bloom Creek at the mouth near Bovill.

Step 1: The mouth of Bloom Creek is in Section 3, Township 41 North, Range 1 East, and the basin is entirely on the U.S. Geological Survey Bovill 15-minute quadrangle map. A continuous-record gage (Station 13341300) was operated at the site (Figure B-9, sheet 1). Records are available from 1959 to 1971. Figures of peak discharge through the 20-year flood computed by the log-Pearson Type III method (Water Resources Council, 1967) are listed in Table B-2. A check of Figure B-9 indicates the design method applies. The site and basin are in Region 1.

Step 2: Table D-1 indicates drainage area (A) is the only basin characteristic that needs to be determined for the Region 1 regression equation. Forest cover (F) also should be determined for evaluation purposes.

Step 3: The drainage area for the Bloom Creek, as previously determined by planimetering from the Bovill quadrangle, is 3.15 square miles. Forest cover (F) is determined to be 101.

Step 4: Using the nomograph or the regression equation and the ratios for Region 1, the 10-year flood is found to be about 135 cfs, the 25-year flood is about 175 cfs, and the 50-year flood is about 200 cfs. From Table B-2, Q10 by the modified log-Pearson Type III method for Bloom Creek is 133 cfs, which closely checks the figure from the nomograph and the equations.

Step 5: No limitation appears to apply to this stream. None of the basin is urbanized. Forest cover index is 101, well above the recommended minimum requirement of 30 for application of the Q25/Q10 and Q50/Q10 ratios. No regulation or diversion that affects the peaks is known. Base flow (the flow after direct runoff from rain or snowmelt has stopped) as observed in late summer is low, indicating no significant effect from groundwater runoff. Alluvium, lava flows, or intense thunderstorms do not appear to affect this area significantly. Also, there are no anomalous areas nearby. Discharge plotted against the drainage area in Figure B-10 appears reasonable compared with plots for nearby streams. For example, a crude check of the data is provided by plotting the 175 cfs (Q25 for Bloom Creek) against its drainage area (3.15 square miles) and comparing it with a plot of Q25 versus the drainage area for East Fork Potlatch River (No. 13341400) and other basins nearby. They appear to plot near the same position with respect to the 100 cfsm line.

Example Two – Application of the Design Method

Determine the 25-year flood for a site on Targhee Creek below the confluence of the East Fork with Targhee Creek.

Step 1: The site is located in the NE 1/4 NE 1/4 of Section 1, Township 16 North, Range 43 East, which is on the U.S. Geological Survey Targhee Pass 7-1/2 minute quadrangle map. The basin lies on Targhee Pass and Targhee Peak 7-1/2 minute quadrangle maps and the Hebgen Dam 15 minute quadrangle map. A crest-stage gage (Station 13038900) was operated from 1963 to 1971 at a site 5 miles downstream (Figure B-9, sheet 3). From Figure B-9, the site and basin are in Region 6.

Step 2: Table D-1 indicates the basin characteristics to be determined are area (A), area of lakes and ponds (La), and latitude of the basin centroid (N). Forest cover should be determined for evaluation purposes.

Step 3:

- A = 10.5
- La = 0.4 + 1.0 = 1.4
- N = 4.7
- F = 44 + 1 = 45

Step 4: Using the appropriate regression equation, a 25-year flood of 136 cfs is indicated. The details of the computation using the regression equation are as follows:

- $Q_{10} = 188\ A^{0.873}\ La^{0.733}\ N^{-1.82}$

$= 188 \times 10.5^{0.873} \times 1.4^{0.773} \times 4.7^{-1.82}$

$= 188 \times 7.79 \times 1.30 \times 0.060 = 113$ cfs

- $Q_{25} = 113 \times 1.2 = 136$ cfs

The peak discharge should be rounded to two significant figures, but were used as computed for ease of checking.

Urbanization or regulation does not affect the peaks. Small diversions for irrigation probably do not affect the peaks because peaks normally occur before the irrigation season. Base flows as observed in late summer is low, indicating no significant effect from groundwater runoff. Alluvium and lava flows do not appear to alter the peak characteristics.

The relative magnitude of the Q_{25} from the nomograph can be compared with a Q_{25} for the crest-stage gage on Targhee Creek (Station 13038900). From Table D-3, Q_{10} for Targhee Creek is 335 cfs. Using the regional ratio for Q_{10}/Q_{25} of 1.2, Q_{25} equals 335 x 1.2 = 402 cfs. The ratio of the drainage areas at the subject site and the crest-stage gage site is 10.5/20.8, or 0.50. On the basis of the drainage area ratio and the record at the crest-stage gage, Q_{25} at the subject site would be 402 x 0.50 =201 cfs. This is 48 percent greater than the 136 cfs from the equation. In Region 6, Q_{50} is only 1.1 times Q_{25}, therefore, the design flood might be chosen on basis of maximum discharges at nearby sites rather than that for a selected recurrence interval. On Figure B-10, maximum discharges at nearby stations, including Stations 1311300, 13047800 and 13051500, plot above and below the Q_{25} of 136 cfs. Because the relation with the gaging station on Targhee Creek indicates a higher discharge and since maximum discharges at several nearby sites are con¬siderably higher, a conservative discharge may be obtained by increasing the Q_{10} discharge by one standard error, or 41 percent (see Table B-1).

Design Discharge = 1.41 (113) 1.2 = 191 cfs

Example Three – Application of the Design Method

Determine the 50-year flood for Cottonwood Creek at the mouth near Horseshoe Bend.

Step 1: The site is in Section 3, Township 6 North, Range 2 East, which is on the Horseshoe Bend 7-1/2 minute quadrangle map. The basin lies on the Horseshoe Bend and Cartwright Canyon 7-1/2 minute quadrangle maps. A crest-stage gage (Station 13248900) was operated at this site from 1961 to 1971. From Figure B-9, sheet 2, the site is in Region 3.

Step 2: Table B-1 indicates the basin characteristics to be computed are area (A), forest cover (F), and latitude of the basin centroid (N).

Step 3:

- A = 6.53 square miles
- F = < 30

$$\text{Forest Factor} = \frac{(31-F)(30^{-0.216} - 31^{-0.216})}{2} + 31^{-0.216}$$

Forest Factor = 0.476

- N = 3.85

Step 4: The nomograph gives a Q50 flood of 440 cfs using the regression equation. The 10- and 50-year floods are as follows:

- $Q_{10} = 3.81A^{0.875}$ (Forest Factor) x $N^{2.02}$

= $3.81 \times 6.53^{0.875} (0.476)\ 3.85^{2.02}$

= $3.81 \times 5.16 \times 0.476 \times 15.2 = 143$ cfs

- $Q_{50} = 143 \times 1.5 = 214$ cfs

Step 5: Urbanization or regulation does not affect the peaks. Field inspection indicates that some flow will bypass the site during extreme floods. Peaks generally occur during the winter and would not be affected by irrigation diversions.

The channel is dry for long periods, indicating that no large springs feed the stream. The generalized geologic map of Idaho (Ross, 1947) shows that above 40 percent of the basin is on granitic rock, which is relatively impermeable, and about 60 percent is on the weakly consolidated sedimentary rocks that are variable in permeability from one location to another. Course alluvium or fractured lava deposits are not extensive. Extreme floods from thunderstorms have been recorded within 20 miles to the southeast (Figure B-11, Sheet 2). There is no significant forest cover on the basin, and forest cover (F) is 0 + 1 = 1. A Q_{10} of 220 cfs by the modified log-Pearson Type II method is reasonably well defined by 10 years of record. However, the Q_{50}/Q_{10} ratio is not well defined for this or other forested basins in any region of the state. Comparison with plots of discharge for nearby streams in Figure B-10 also indicates a wide divergence of peak flows for this area.

Because of uncertainties of the definition of discharges at long recurrence intervals, the designer should consider several alternatives. No intense thunderstorms have been recorded in the immediate area, although some have been experienced just over the ridge to the south [see Site M13207650 (Figure B-11, Sheet 2, and Table B-3) and others on the Boise front, near Boise (Figure B-11, Sheet 2)]. In addition to the thunderstorm floods nearby, maximums for Big Willow Creek near Emmett, Fourmile Creek near Emmett, Bryans Run near Boise, Spring Valley Creek near Eagle, and the magnitude and frequency data for the subject site should be considered in assessing the flood potential and risk at long recurrence intervals.

A reasonable design discharge for all but the extremely rare events could be determined by increasing the Q_{50} discharge by percentages equivalent to one standard error as follows: Q_{50} at the site was determined to be 450 cfs. Standard error for Region 3 is 51 percent. Increasing 450 by 51 percent gives a more conservative discharge of 680 cfs. If damage would be extreme from a structural failure, a discharge equivalent in percent to some larger multiple of the standard error may be added to the discharge from the nomograph.

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FIGURE 2.--MAP OF IDAHO SHOWING BASIN BOUNDARIES AND MAXIMUM KNOWN UNIT DISCHARGES AT MISCELLANEOUS SITES.

B.40.03 Undefined Areas Where Regression Relations Do Not Apply. Regional regression relations should apply to areas that are homogenous with respect to variables that affect the flow. Regression equations may not apply to basins in which the basin or flow characteristics are outside the range of those characteristics used to define the regional regression relations. Variations in topography, climate, geology, land use, and regulation or stream flow in Idaho often result in abrupt changes in flow and basin characteristics. Some of these variations are inadequately defined by available data. The following sections describe the poorly defined areas and discuss the reasons the regression relations are inapplicable.

Areas in which regional regression relations are not defined total about 20,000 square miles and are outlined in Figure B-9. In addition to these areas, smaller undelineated areas are scattered throughout Idaho.

In general, the undefined areas are mostly arid or semiarid. Stream flow in small streams is usually ephemeral (flowing only in direct response to precipitation or short-lived snowmelt) or intermittent (flowing only part of the time, such as during the snowmelt period or during wet periods in winter). Records are sparse and short in length. Therefore, flood flow magnitudes and frequencies have not been defined.

In addition to areas of poor definition, peak flows in many small basins are affected by urbaniza¬tion, regulation, significant quantities of groundwater runoff, and large losses or gains associated with alluvial valleys and lava flows, intense thunderstorms, unusual climatic or physical basin characteristics, or a combination of these factors.

1. Unforested Areas

Most of the unforested areas of the state are in the arid or semiarid areas where precipitation is too low to support forestation. Nearly all of the area designated as undefined in Figure B-9 are unforested. Small streams are usually ephemeral or intermittent and the volume of runoff is low. Only a few records are available to define the magnitude and frequency of floods on these areas, and very few records are available to define the Q_{25}/Q_{10} and Q_{50}/Q_{10} ratios.

Because a small percentage of forest cover appears to be indicative of the ephemerality of streams in small basins, basins with less than 30 percent forest cover ($F < 30$) are assumed not defined by methods used in this report.

Judgment and the maximum unit discharge of record for nearby streams, as shown in Figure B-11, are the best bases that can be recommended for the determination of discharge in unforested basins.

2. Urbanized Areas

Urbanization drastically changes basin features, which increase in paved areas, and the addition of sewerage are the most obvious. Both decrease the concentration time of the basin, which increases the intensity of floods and the frequency of flooding. Climates have been observed to change in or near large cities. Precipitation, temperature, humidity, cloudiness, and wind speed may be altered to some degree in urban areas. Also, urbanization is often accompanied by infringements on the natural flood channel and the flood plain, thus increasing flood heights. On the other hand, storm sewers may bypass surface flows past some sites, thus reducing peaks in natural channels.

Studies in other parts of the country indicate that for a basin of 1 square mile that is completely storm sewered and whose surface is completely (or 100 percent) impervious, the mean annual flood (approximately the 2-year flood) is about eight times larger than for the natural basin. The mean annual flood from a basin of 1 square mile that is completely storm sewered but 0 percent impervious is about 1.7 times as large as the natural basin. The mean annual flood for a basin that is completely impervious but not sewered is about 2.5 times as large as for the natural basin (Leopold, 1968). Very little information of this type is available regarding discharges from urbanized areas in Idaho.

3. Regulated Streams

South of about 45o 30' north latitude, most agriculture (except grazing and dry farming) requires irrigation. Roughly 5,500 sq. mi. (or nearly 7 percent of the total area of the state) is irrigated, of which nearly 80 percent is irrigated from surface streams. Irrigated areas in the state are shown in Figure B-9.

Streams that reach the irrigated lands may be affected by one or a combination of the following: regulation, diversion, consumptive use, and return flow from irrigation. The impact on natural flood peaks is significant. Peak flows in many natural channels are drastically reduced and regional regression equations usually do not apply directly.

Determination of realistic design discharges requires that manmade effects be considered. Sources of data for estimating peak flows in these streams include records of performance of existing structures such as canals, bridges, ditches, drains, etc.; watermaster records of water use; streamflow records; verbal reports from local residents; and estimates of natural peak flows using basin characteristics. Contributing areas upstream during flood periods are sometimes difficult to define because of storage in reservoirs or upstream diversions that may divert floodwater outside the basin. Composite effects from works of man including canals, roads, levees, dams, and storage behind fills during floods are difficult to evaluate. Only a few floods have been measured in channels of this type and most of these have been on large streams.

Flows in Robbers Roost Creek (13073700), Spring Valley Creek (13207000), Morse Creek (13301800), and Twelve Mile Creek (13302200) in Table B-3 are known to be affected by diversions above the gaging sites. Likewise, floods in "D" drain tributary (M13084800), "F" drain, and some others listed in Table B-3 may be affected in varying degrees by works of man.

4. Streams With Losing or Gaining Reaches

A large number of streams, both large and small, gain or lose flow by interaction with the groundwater system. Streams flowing over permeable formations tend to gain in discharge if they are below adjacent groundwater tables and lose if above them. These streams are especially common in the areas marked "undefined" in Figure B-9. The characteristics of floods in such streams can be very different from streams fed more directly by overland flow.

Peaks in gaining reaches may be greatly subdued because all or part of the peak flow origi¬nates from groundwater runoff, which is regulated by slowly changing water tables. For example, the discharge of Birch Creek near Reno (Station 13117000) is practically all groundwater runoff that originates a few miles above the gage. The maximum flow in 15 years of record is 220 cfs (Table B-3). This peak flow is only 2.8 times the average dis¬charge for the period of record. The channel is usually dry over the alluvium above the reach of discharge from groundwater. The stream then loses below the gage, never flowing past the Birch Creek Sinks about 30 miles downstream. A more normal stream nearby, Sawmill Creek near Goldburg (13117300), had a maximum flow of 651 cfs in 10 years of records, which is 13.4 times its average flow for the period.

Other streams, such as Cub River near Preston (10093000) and Birch Creek near Downey (13074000), are fed by large underground flows from solution cavities in limestone mountains and respond relatively quickly to changing rates of snowmelt. They may drain areas much larger or smaller than their surface drainage indicates. Flood flows in such streams may be at high rates while the flooding in adjacent streams may be considerably smaller.

A decrease in flood discharge occurs in many small streams as they flow from the impervious rocks of the mountain ranges onto the alluvial valleys. Peak flows are often further decreased by diversion for irrigation. For example, the maximum discharge of record for Morse Creek above diversions near May (13301700) is 230 cfs, while the maximum for Morse Creek near May (13301800), 2.7 miles downstream, across an alluvial fan, and below irrigation diversions, was 81 cfs.

Stream channels known to be affected by significantly large gains or losses are shown in Figure B-9. Data other than or in addition to the discharge determined by regional regression equations are needed in these areas.

5. Alluvial Valleys and the Snake Plain

Closely related to the streams with losing or gaining reaches, discussed previously, are streams draining basins entirely in alluvial or glacial valleys or on the Snake Plain. Other basins include both mountain and valley areas. Large areas of intermontane valleys and lowlands are underlain by deep alluvium. Other areas, especially the Snake Plain, are underlain by fractured basalt, and both types of formation can absorb large quantities of floodwater. Percolation rates are considerably reduced by deep soil cover or by lacustrine deposits, both of which vary considerably in thickness, extent, and permeability.

In most years, floods are not generated on the alluvial valleys and plains because the rate of infiltration greatly exceeds the snowmelt or precipitation rate. Natural streams are ephemeral unless the channel intercepts the groundwater table, in which case the stream is intermittent or perennial. Large parts of the Snake Plain are unchannelized or have very poorly developed channels, indicating that overland flow may be rare and short-lived.

Occasionally as the snow melts, the melt water freezes in place and a glaze is formed over the permeable alluvial or basaltic surfaces, making the surface very impermeable. If more snow accumulates and a quick snowmelt then occurs, high rates of runoff result. The floods of February 1962, February 1963, and December 1964 resulted from this sequence of hydrologic conditions and caused extensive flooding on the lowland areas of southern Idaho. Many miscellaneous measurements of these flood discharges were obtained and are shown within basin boundaries (Figure B-11). The measurement results are listed in Table B-3. No frequency data are available for this type of flood, but the data are indicative of the size of flood that can be expected from this type of event.

Much of the irrigated land in the state is in this area, and natural streams are usually affected by regulation, diversions, return flow, or changing land use (Figure B-9).

6. Intense Thunderstorm-Prone Areas

Intense thunderstorms may produce rates of runoff in small basins that are much higher than those computed using the regression equation. Of the peak discharges listed in Table B-3, those that were summer floods and were not associated with snowmelt were assumed to be caused by intense thunderstorms. Of those, 11 discharges exceeded 1,000 cfsm, of which three were higher than 5,000 cfsm. Five more measurements showed rates between 500 and 1,000 cfsm, 13 showed rates between 500 and 1,000 cfsm, and 13 showed rates between 100 and 500 cfsm. Reference to Figure B-11 and the "Relative Magnitude of Floods" section indicates that most of the extremely high rates of runoff of record in Idaho are caused by intense thunderstorms. Storm cells are often small and may be confined to a small part of the basin.

All of the intense thunderstorm-prone areas measured to date are essentially unforested, except Canyon Creek tributary near Lowman, which is only sparsely forested. Practically all of the extreme floods caused by thunderstorms, which have been documented, are in southern Idaho near the Snake Plane except for a few floods near Lewiston. Areas near the Boise front, in the Portneuf-Bear River section, and near American Falls, Murphy, Bruneau, and Lewiston appear to occur near the foothills or the base of the mountains adjacent to extensive valley areas such as the Snake Plain, Cache Valley, or Columbia Basin.

No series of annual peak flows has been established for any of these intense thunderstorm-produced floods and recurrence intervals have not been established. Probably the best basis for establishment of recurrence intervals at a design site would be from the newspaper or other local accounts. Hazard from this type of flood does exist and should be considered when designing structures for several areas of the state.

7. Anomalous Areas

Variations in topography, geology, climate, and land use are extreme in the state. The basin characteristics determined do not define all combinations of these variables, and the effects of the variables on flood flows have not been defined by the limited number of sites where flow data have been collected. The discharges given by the simplified equations proposed do not fit all the records of discharge within reasonable limits. The actual discharge for a given recurrence interval for some ungaged streams will likewise be more or less than the discharge given by the regression equations of this report.

Table B-4 is a list of the gaged sites for which the Q_{10}, determined by the modified log-Pearson Type III method, exceeds or is less than the Q_{10} from the regression equations by more than 70 percent. Reasons for departures from regional data are not always apparent, but at nearly all sites listed in Table B-4, several flood events have been recorded that exceed or were less than the regional 10- or even 50-year peaks as determined by the applicable regional equations. Reference to Table B-4 will enable users to determine areas where peaks of records are well above or below the estimated discharges using the regional equations.

The percentage of departure of an anomalous area from the regional data can be used as a guide in the application of the regional data to ungaged small streams. Estimates of peak flow for streams within anomalous basins or for nearby basins that appear to have similar flow or basin characteristics can be raised or lowered accordingly, especially if underdesigning or overdesigning would result in extensive damage or prohibitive costs.

Sources of Information

The U.S. Geological Survey publishes streamflow data for Idaho and is the major source of streamflow information. Each volume of the series of Geological Survey water-supply papers entitled "Surface Water Supply of the United States" contains a listing of the numbers of all water-supply papers in which records of surface-water data were published for the area covered by that volume. Each volume also contains a list of water-supply papers that give detailed information on major floods for the area.

Records through September 1950 for the state have been compiled and published in Water-Supply Papers 1314, 1316, and 1317. Records for October 1950 to September 1960 have been compiled and published in Water-Supply Papers 1734, 1736, and 1737. These reports contain summaries of monthly and annual discharge or month-end storage for all previously published records, as well as some records not contained in the annual series of water-supply papers. The yearly sum¬mary table for each gaging station lists the numbers of the water-supply papers in which daily records were published for that station.

The new series of water-supply papers containing daily surface-water records for the 5-year period from October 1, 1960 to September 31, 1965 (Water-Supply Papers 1927, 1933, and 1935) also contain lists of annual and special reports published as water-supply papers.

Records since October 1, 1965, are published in annual volumes entitled "Water Resources Data for Idaho."

Discharge measurements made at miscellaneous sites and peak discharges at partial-record stations are compiled for the period 1894-1967 in a special basic-data report, "Miscellaneous Streamflow Measurements in Idaho, 1894-1967."

Special reports on major floods or droughts or other hydrologic studies for the area have been issued in publications other than water-supply papers. Information relative to these reports may be obtained from the U.S. Geological Survey.

Table B-4

GAGING STATIONS AT WHICH THE Q10 IS DETERMINED BY THE MODIFIED log-PEARSON METHOD DIFFERS BY MORE THAN 70 % FROM THE Q10 DETERMINED BY THE REGIONAL EQUATION

	Station No.	Station Name	Difference (percent)
2	13302200	Twelvemile Creek near Salmon	-72
2	13336100	Meadow Creek near Lowell	206
2	13348400	Missouri Flat Creek Tributary near Pullman, WA	208
3	13154000	Clover Creek near Bliss	97
3	13155000	King Hill Creek near King Hill	142
3	13238300	Deep Creek near McCall	203
3	13240000	Lake Fork above Jump Creek, near McCall	80
3	13240500	Lake Fork above reservoir, near McCall	75
3	13249000	Squaw Creek near Gross	214
3	13290150	North Fork Pine Creek near Homestead, OR	218
3	13335200	Critchfield Draw near Clarkston, WA	156
4	13172680	Reynolds Creek Station W4	143
4	13172725	Reynolds Creek Station W12	323
4	13172730	Reynolds Creek Station W11	121
4	13172740	Reynolds Creek Station W1	135
4	13235100	Rock Creek at Lowman	137
5	13293000	Alturas Lake Creek near Obsidian	96
5	13297300	Holman Creek near Clayton	-75
5	13298300	Malm Gulch near Clayton	364
6	13027200	Bear Canyon near Freedom	130
6	13057600	Homer Creek near Herman	85
7	13075700	South Fork Pocatello Creek near Pocatello	-70
7	10084500	Cottonwood Creek near Cleveland	122
7	10090800	Battle Creek Tributary near Teasureton	164
7	10096500	Maple Creek near Franklin	98
7	10099000	High Creek near Richmond	120
7	13062700	Angus Creek near Henry	262
8	13161300	Meadow Creek near Rockland, NV	106
8	13162200	Jarbridge River at Jarbridge, NV	120

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Gaging Station Numbering System

Each gaging station and partial-record station has been assigned a number in downstream order in accordance with the permanent numbering system used by the U.S. Geological Survey. Numbers are assigned in a downstream direction along the main stream, and stations on tributaries between mainstream stations are numbered in the order they enter the main stream. A similar order is followed on other ranks of tributaries. The complete 8-digit number, such as 13038900, includes the part number "13" plus a 6-digit station number. Miscellaneous measurement sites are designated by the letter "M" preceding the station number.

B.40.04 *Using Channel Geometry to Estimate Flood Flows at Ungaged Sites in Idaho* by U.S. Geological Survey; Water-Resources Investigations 80-32. The following is a summary of a portion of this report: Equations using Q_{200} and Q_{500} as dependent variables are not presented because of the uncertainties associated with extending the frequency curve too far. Most of the gaging stations used have less than 25 years of record.

Application to Ungaged Sites

Use following procedure for bankfull width to estimate peak discharges at ungaged sites:

1. At the site of interest, make 5 to 10 measurements of bankfull width and average them. The measurements should be at least a channel width apart and at the level of bankfull discharge. Riggs (1974), in describing his whole-channel section, said, "The reference level for this section is variously defined by breaks in bank slope, by the edges of the flood plain, or by the lower limits of permanent vegetation." Wahl (1977) pointed out that on perennial streams, this is virtually the same as bankfull stage as described by Leopold, Wolman, and Miller (1964). More detailed descriptions are available in Emmett (1975) and Lowham (1976).

2. Use either of the sets of equations below to solve an estimate of the peak of interest:

   $Q_{1.25}$ = 0.43 WB1.78 SE = 98%, -49%

   Q_2 = 0.76 WB1.73 SE = 92%, -48%

   Q_5 = 1.31 WB1.68 SE = 90%, -47%

   Q_{10} = 1.73 WB1.66 SE = 90%, -47%

   Q_{25} = 2.29 WB1.64 SE = 92%, -48%

   Q_{50} = 2.73 WB1.62 SE = 93%, -48%

   Q_{100} = 3.21 WB1.61 SE = 95%, -49%

   or:

$Q_{1.25}$ = 0.48 AREA0.33 (I24_2)1.21 WB1.22 SE = 79%, -44%

Q_2 = 0.94 AREA0.34 (I24_2)1.06 WB1.16 SE = 74%, -42%

Q_5 = 1.74 AREA0.35 (I24_2)0.93 WB1.10 SE = 72%, -42%

Q_{10} = 2.37 AREA0.35 (I24_2)0.86 WB1.07 SE = 73%, -42%

Q_{25} = 3.24 AREA0.36 (I24_2)0.81 WB1.03 SE = 75%, -43%

Q_{50} = 3.92 AREA0.37 (I24_2)0.78 WB1.01 SE = 77%, -43%

Q_{100} = 4.65 AREA0.37 (I24_2)0.78 WB.99 SE = 79%, -44%

The first set of equations requires that only WB be measured to make an estimate of the selected peak discharge(s). The second set requires that AREA and I24_2 also be obtained. The second set is included because the estimated peaks may be better estimates, as indicated by the lower standard error.

If the second set of equations is used, an estimate of I24_2 must be made. The map on Figure B-12 (three sheets) can be used to determine the correct value for each drainage basin of interest. The drainage basin should be located on the map and an average value of I24_2 selected.

Definitions

AREA – Drainage area in square miles.

I24_2 – Precipitation intensity in inches for a 24-hour period with a recurrence interval of 2 years.

Q1.25 – Peak discharge in cubic feet per second with a recurrence interval of 1.25 years.

Q2 to Q100 – Peak discharges for recurrence intervals of 2 to 100 years.

SE – Standard error in percent. The two figures following SE show the plus and minus percentages and the result because variables were computed in logarithmic form.

WB – Width of water surface at bankfull stage (average of 5 to 10 field measurements).

Conclusions

The study shows that estimates of flood flows can be made at ungaged sites in Idaho by using regression equations that relate selected floods to bankfull width or bankfull area.

The study indicates that estimates of flood flow made by using channel measurements as the independent variable are slightly better than estimates made by using basin characteristics as the independent variable. It also indicates that estimates made by using both basin and channel characteristics as the independent variables are even better.

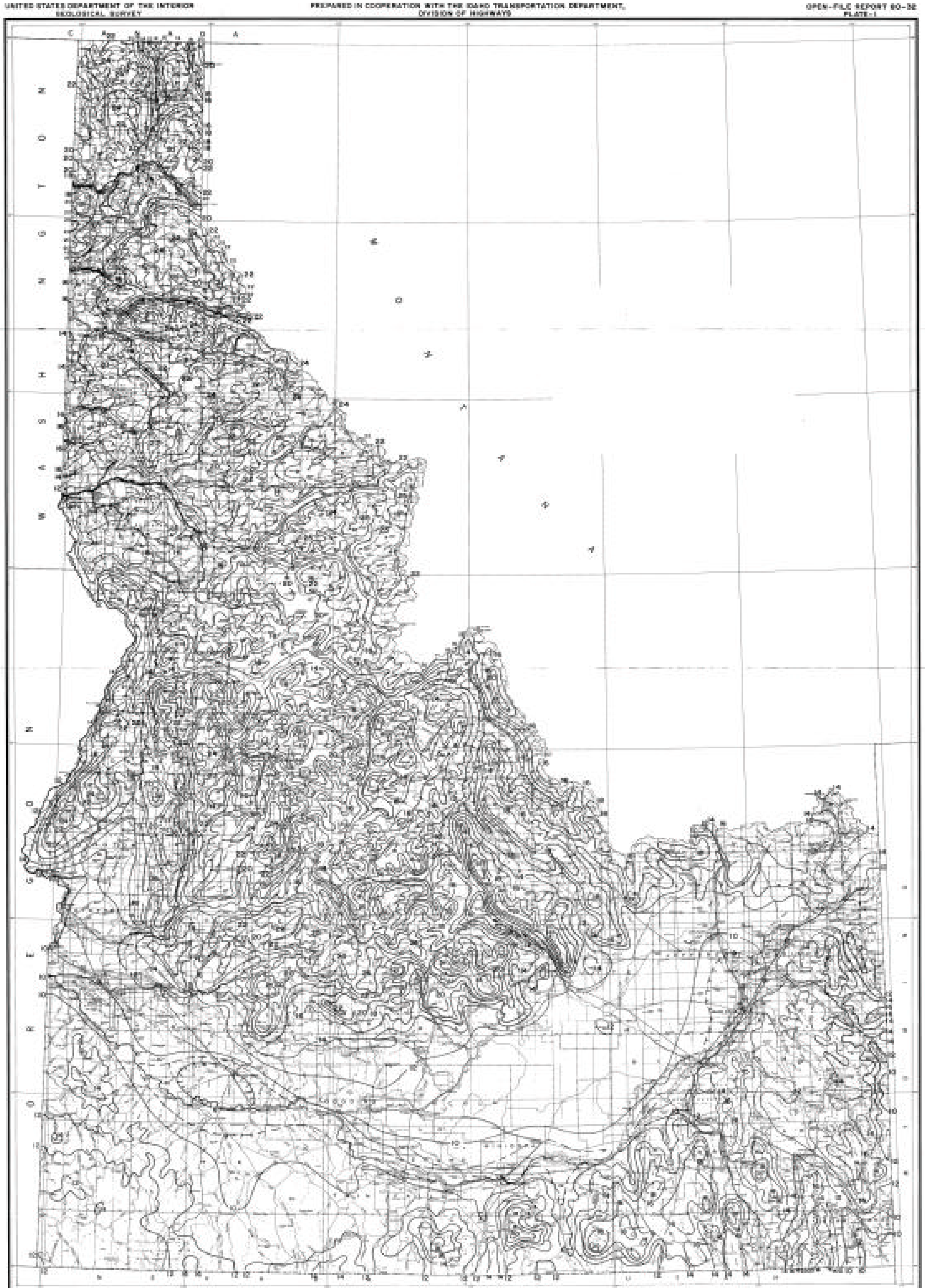
Figure B-12

2 - YEAR, 24 HOUR PRECIPITAION INTENSITY MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE IDAHO TRANSPORTATION DEPARTMENT,
DIVISION OF HIGHWAYS

OPEN-FILE REPORT 80-32
PLATE-1



DISTRIBUTION OF 2-YEAR, 24-HOUR PRECIPITATION INTENSITY FOR IDAHO

B.40.05 *A Method of Estimating Flood-Frequency Parameters for Streams in Idaho* by U.S. Geological Survey, Open-File Report 81-909.

The following is a summary of a portion of this report: The report was modified for ITD projects with forest cover between 0 and 30 percent. It was discovered that abnormally high results were obtained for watersheds with a low percentage of forest cover. Details are shown in Figure B-13. The revision was reviewed and concurred with by L. C. Kjelstrom and W. A. Harenberg of the U.S. Geological Survey.

Flood-Frequency Analysis for Ungaged Sites

Estimates of the most important statistic of the log-Pearson Type III distribution – the mean logarithm of annual peak discharges – can be predicted by basin characteristics. If reasonable estimates of the standard deviation of logarithms of annual peak discharges, which ranged from 0.084 to 0.538, could also be predicted by basin characteristics, the log-Pearson Type III equation could be used to develop a frequency curve for ungaged sites. Because generalized skew coefficients seem to give reasonable results when used directly for the 120 stations having less than 25 years of record, the generalized skew maps can also provide estimates of skew for ungaged basins. Regression analyses of the mean and standard deviations of logarithms of annual peaks with basin characteristics were made using 269 gaging stations (Figure B-14) having 10 or more years of systematic record.

After investigating several methods, it was determined that the two statistics could best be predicted by: (1) regionalizing the data on the basis of significant basin characteristics, for example, drainage area, mean altitude, and mean annual precipitation; and (2) separating the regionalized data by basin size. The comparison of various regression equations, correlation coefficients, and computer plots of dependent and independent variables aided in defining the regions and drainage basin sizes in some cases where different sets of variables were effective. Some subjective judgment was necessary to make the finer distinctions, but the division into subareas and drainage size was largely dictated from analyzing the data. For this study, the area was divided into three regions on the basis of similarity of basin characteristic effect; each region was analyzed separately (Figure B-15).

For both the mean and standard deviation in region 1 and the standard deviations in regions 2 and 3, a separation of basin size was required because of changes in statistically significant basin characteristics. Regression equations for region 1 could not be defined for drainage basins greater than 250 square miles because nearly all larger basins are affected by diversions or regulation. Multiple regression was done by using stepwise and step-backward techniques. Regression equations (Figure B-13) with two or three independent variables were selected on the basis of coefficients of determination, correlation coefficients, and statistical tests. The form of the equations remains in logarithmic units so an estimate of the statistics can be used in the log-Pearson Type III equation.

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Figure B-13

Regionalized Regression Equations for Annual Maximum Discharges

Region	See Figure 6 for division of Regions.	MAP	Mean Annual Precipitation.
DA	Drainage Area, in square miles.	ALT	Mean Altitude of the Basin.
S	Average Slope of Main Channel between points at 85 and 10 percent of the length above the gage to the basin divide. Units are feet per mile.	INT24HR	Rainfall Intensity of a 24-hour period at the 50 percent exceedance probability.
F	Percentage of Forest Cover plus 1 percent.	MMJT	Mean Minimum January Temperature.

MODIFICATION FOR USE ON ITD PROJECTS

1. Delete -0.157xlogF (as shown) from appropriate equations in Regions 2 & 3 (DA greater than 250 square miles.)
2. Multiply computed Q by Forest Factor, defined below, when calculated from these same two equations.

PERCENT FOREST = 0-30	PERCENT FOREST = 30-100
Forest Factor = $\dfrac{(10^{(-0.157xKxlog\ 30)} - 10^{(-0.157xKxlog\ 32)})(31-F)}{2} + 10^{(-0.157xKxlog\ 30)}$	Forest Factor = $10^{(-0.157xKxlog\ F)}$

Region	Drainage area (mi)	**M = MEAN LOG** Regression equation for mean logarithm of annual maximum discharges	**S = STANDARD DEVIATION** Regression equation for standard deviation of logarithms of annual maximum discharges	**Q = DISCHARGE** **K = FREQUENCY FACTOR** for log-Pearson Type III distribution, determined from Skew & desired frequency
1	$\leq$35	1.477 + 1.280 log DA - 0.399 log S	3.289 – 0.175 log DA – 0.739 log ALT	$Q = 10^{(M + KS)}$
	>35 to <250	0.637 + 0.808 log DA + 0.155 log F	3.250 - 0.083 log F - 0.732 log ALT - 0.523 log INT24HR	$Q = 10^{(M + KS)}$
2	$\leq$250	-0.037 + 0.839 log DA + 0.834 log MAP	1.877 - 0.067 log DA - 0.193 log MAP - 0.337 log ALT	$Q = 10^{(M + KS)}$
	>250	-0.037 + 0.839 log DA + 0.834 log MAP	0.600 – 0.157 log F –0.123 log MAP + 0.060 log MMJT	$Q = (\text{Forest Factor})(10^{(M + KS)})$
3	$\leq$250	0.800 + 0.993 log DA + 0.169 log S	0.751 - 0.050 log DA - 0.111 log ALT - 0.057 log MAP	$Q = 10^{(M + KS)}$
	>250	0.800 + 0.993 log DA + 0.169 log S	0.600 – 0.157 log F – 0.123 log MAP + 0.060 log MMJT	$Q = (\text{Forest Factor})(10^{(M + KS)})$

Data Table B14. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution
(PCT: Percent chance of exceedance, MAX_PEAK: Maximum known peak, and YRS_REC: Years of systematic record.)

STA_NO	STA_NAME	Discharge, in ft^3/s _50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
06013500	BIG SHEEP C BELOW MUDDY CREEK NR DELL, MT	344	643	792	901	1010	909	04-18-52	26
06015500	GRASSHOPPER C NR DILLON, MT	392	891	1170	1380	1600	1870	03-24-56	39
06019500	RUBY R ABOVE RES. NR ALDER, MT	939	1360	1550	1670	1800	1700	06-08-72	40
06026000	BIRCH C NR GLEN, MT	207	329	383	421	457	427	07-05-75	30
06033000	BOULDER R NR BOULDER, MT	1120	2180	2740	3160	3580	3500	06-19-75	44
06037500	MADISON R NR WEST YELLOWSTONE, MT	1330	1790	1990	2120	2240	2150	05-24-56	59
06043500	GALLATIN R NR GALLATIN GATEWAY, MT	5150	7740	8840	9590	10300	9890	06-17-74	53
09208000	LA BARGE C NR LA BARGE MEADOWS R S, WY	131	185	208	223	237	196	06-16-72	29
09223000	HAMS FORK BELOW POLE C NR FRONTIER, WY	870	1130	1230	1290	1360	1520	05-26-71	25
10015700	SULPHUR C ABOVE RES. NR EVANSTON, WY	351	665	894	1100	1350	1220	04-21-65	20
10041000	THOMAS FORK NR mY/– ID STATE LINE	454	886	1100	1250	1390	1040	05-14-71	28
10047500	MONTPELIER C AT IRRIGATORS WEIR MONTPELIER ID	96	173	211	239	265	224	05-18-50	29
10058600	BLOOMINGTON C AT BLOOMINGTON, ID	153	207	229	243	256	248	06-11-71	16
10069000	GEORGETOWN C NR GEORGETOWN, ID	53	89	110	127	•	162	06-08-12	19
10072800	EIGHTMILE C NR SODA SPRINGS, ID	111	147	162	171	180	160	06-18-71	17
10084500	COTTONWOOD C NR CLEVELAND, ID	346	622	756	853	947	788	05-16-75	39
10090800	BATTLE C TRIBUTARY NR TREASURETON, ID	37	128	208	287	•	98	02-01-63	16
10093000	CUB R NR PRESTON, ID	581	732	790	828	862	803	06-11-71	35
10119000	L MALAD R AB ELKHORN RES. NR MALAD CITY, ID	103	343	569	804	1110	1450	02-10-62	32
10132500	LOST C NR CROYDON, UT	232	528	700	834	973	770	05-10-23	28
10172970	ROCK C NR HOLBROOK, ID	104	340	546	750	1010	1390	02-11-62	16
10315500	MARYS R ABOVE HOT SPRINGS C NR DEETH, NV	344	864	1240	1580	1970	4210	02-12-62	35
10316500	LAMOILLE C NR LAMOILLE, NV	408	592	673	731	786	794	06-04-57	40
10317500	N F HUMBOLDT R AT DEVILS GATE NR HALLECK, NV	577	1970	3160	4310	5740	10400	02-11-62	41
10324500	ROCK C NR BATTLE MOUNTAIN, NV	455	1710	2900	4230	5980	4800	02-11-62	39
10329000	L HUMBOLDT R NR PARADISE VALLEY, NV	104	534	1000	1520	2220	2380	01-21-69	37
10329500	MARTIN C NR PARADISE VALLEY, NV	360	1460	2920	4670	7260	9000	01-21-43	54
10352500	MCDERMITT C NR MCDERMITT, NV	540	1960	3250	4740	6710	3970	02-01-63	29
10353000	EF QUINN R NR MCDERMITT, NV	390	895	1220	1540	1900	1270	01-15-56	29
10396000	DONNER UND BLITZEN NR FRENCHGLEN, OR	1300	2670	3400	3960	4530	4270	04-26-78	52
10403000	SILVER C NR RILEY, OR	564	1420	1960	2420	2910	1810	12-22-64	27
10406500	TROUT C NR DENIO, NV	108	237	312	371	434	470	08-01-33	57
12302500	GRANITE C NR LIBBY, MT	619	1180	1520	1810	2120	1960	04-18-38	22
12304500	YAAK R NR TROY, MT	7570	10900	12600	13800	15000	13400	05-20-54	24
12305500	BOULDER C NR LEONIA, ID	1250	1950	2450	3000	4100	3140	01-16-74	47
12307500	MOYIE R AT EILEEN, ID	6530	9080	10200	11000	11700	11000	05-20-54	52
12310800	TRAIL C AT NAPLES, ID	160	328	443	544	660	1100	01-16-74	17
12311000	DEEP C AT MORAVIA, ID	1050	1570	2070	2650	3500	4400	01-15-74	44
12313500	BALL C NR BONNERS FERRY, ID	542	1220	1660	2030	•	2180	06-17-74	14
12316800	MISSION C NR COPELAND, ID	340	471	532	577	620	528	05-26-16	20
12320500	LONG CANYON C NR PORTHILL, ID	593	947	1130	1270	1420	1300	05-27-48	32
12321000	SMITH C NR PORTHILL, ID	1910	2880	3370	3720	4080	3810	06-23-55	43
12321500	BOUNDARY C NR PORTHILL, ID	1930	2840	3270	3600	3920	3540	06-02-68	49
12332000	M F ROCK C NR PHILIPSBURG, MT	908	1420	1640	1790	1930	1590	06-02-72	39
12392100	TRAPPER C NR CLARK FORK, ID	40	88	121	148	179	230	01-16-74	17
12392300	PACK R NR COLBURN, ID	2470	3860	4610	5190	5790	6880	01-16-74	20
12392800	HORNBY C NR DOVER, ID	36	49	56	61	•	48	02-10-61	11
12393600	BINARCH C NR COOLIN, ID	66	132	172	204	237	158	01-15-74	16
12394000	PRIEST R NR COOLIN, ID	5830	7510	8260	8790	9300	8900	06-18-74	29
12395000	PRIEST R NR PRIEST RIVER, ID	6750	8840	9730	10300	10900	10500	05-29-48	47
12396000	CALISPELL C NR DALDENA, WA	475	1030	1660	2700	4230	3190	01-15-74	27
12411000	COEUR D'ALENE R AB SHOSHONE C NR PRICHARD, ID	7030	12300	1530	17600	20100	22000	01-15-74	36
12413000	COEUR D'ALENE R AT ANAVILLE, ID	15600	28100	43300	57500	74500	61000	01-16-74	37
12413100	BOULDER C AT MULLAN, ID	100	173	215	247	281	220	06-03-74	17
12413140	PLACER C AT WALLACE, ID	341	643	824	969	1120	1300	1964	18

Data Table B14. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft^3/s							
STA_NO	STA_NAME	_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
12413200	MONTGOMERY C NR KELLOGG, ID	72	160	218	288	•	155	01-31-71	10
12413500	COEUR D'ALENE NR CATALDO, ID	18900	36700	51500	69000	90100	79000	01-16-74	54
12413700	LATOUR C NR CATALDO, ID	608	1140	1450	1700	•	1900	01-16-74	10
12414500	ST. JOE R AT CALDER, ID	16400	26200	32200	38400	45400	53000	12-23-33	59
12414900	ST. MARIES R NR SANTA, ID	2470	5450	7370	8980	•	10700	01-15-74	13
12415000	ST. MARIES R AT LOTUS, ID	4780	10900	15200	19000	23500	23800	12-22-33	44
12415100	CHERRY C NR ST. MARIES, ID	115	198	245	283	•	317	01-16-74	12
12415200	PLUMMER C TRIB AT PLUMMER, ID	67	115	140	161	182	150	01-15-74	16
12416000	HAYDEN C BW NORTH FORK, NR HAYDEN LAKE, ID	328	644	825	968	1120	790	12-23-64	23
12424000	HANGMAN C AT SPOKANE, WA	7170	14100	18400	21900	25600	20600	02-03-63	30
12427000	LITTLE SPOKANE R AT ELK, WA	108	149	169	184	193	205	01-16-74	29
12431000	LITTLE SPOKANE R AT DARTFORD, WA	1490	2360	2800	3130	3460	3170	02-17-70	35
12465000	CRAB C AT IRBY, WA	1120	4310	7070	9720	12900	8370	02-27-57	35
13011500	PACIFIC C AT MORAN, WY	2460	3300	3650	3880	4090	3790	06-15-74	31
13011900	BUFFALO FORK AB LAVA C, NR MORAN, WY	4250	5200	5570	5810	•	6020	06-19-74	12
13014500	GROS VENTRE R AT KELLY, WY	3100	4590	5290	5790	•	8960	06-16-18	15
13023000	GREYS R ABOVE RES. NR ALPINE, WY	3420	5280	6110	6690	7240	7230	06-19-71	25
13024500	COTTONWOOD C NR SMOOT, WY	243	360	411	445	479	438	06-02-56	25
13025000	SWIFT C NR AFTON, WY	506	710	795	853	907	793	07-06-75	36
13025500	CROW C NR FAIRVIEW, WY	227	334	379	411	•	346	02-01-63	10
13027500	SALT R ABOVE RES. NR ETNA, WY	2140	3510	4130	4570	4980	3870	06-01-71	23
13029500	MCCOY C ABOVE RES. NR ALPINE, ID	915	1330	1500	1610	1720	1670	05-10-74	19
13030000	INDIAN C ABOVE RES. NR ALPINE, ID	207	304	345	373	400	350	06-14-18	18
13030500	ELK C ABOVE RES. NR IRWIN, ID	476	702	799	866	928	870	05-15-18	18
13032000	BEAR C ABOVE RES. NR IRWIN, ID	521	754	853	920	983	784	05-05-36	22
13038900	TARGHEE C NR MACKS INN, ID	274	379	423	452	479	458	05-23-70	15
13044500	WARM R AT WARM RIVER, ID	467	729	846	928	1000	900	05-02-12	18
13045500	ROBINSON C AT WARM RIVER, ID	596	998	1180	1320	1440	1140	05-28-12	18
13047500	FALL R NR SQUIRREL, ID	3480	4790	5370	4770	6150	6440	06-27-27	65
13050700	MAIL CABIN C NR VICTOR, ID	39	59	68	74	•	81	05-21-71	10
13050800	MOOSE C NR VICTOR, ID	281	371	407	431	•	390	06-23-71	10
13052200	TETON R ABOVE S LEIGH C NR DRIGGS, ID	1290	2030	2350	2580	2800	2270	05-19-74	22
13054400	MILK C NR TETONIA, ID	102	519	891	1250	1670	1350	02-01-53	16
13055000	TETON R NR ST. ANTHONY, ID	3260	5270	6320	7120	7940	11000	02-12-52	67
13058000	WILLOW C NR RIRIE, ID	1720	3130	3890	4490	5100	5080	02-11-62	25
13061100	SNAKE R TRIB NR OSGOOD, ID	89	330	540	747	1000	450	01-21-69	17
13062700	ANGUS C NR HENRY, ID	266	667	906	1100	•	1060	05-11-76	13
13063000	BLACKFOOT R ABOVE RES. NR HENRY, ID	1260	2140	2550	2840	3120	2150	04-26-74	22
13063500	L BLACKFOOT R AT HENRY, ID	143	254	307	346	•	292	04-19-14	12
13068500	BLACKFOOT R NR BLACKFOOT, ID	1650	2650	3130	3490	3840	3500	05-01-52	55
13073700	ROBBERS ROOST C NR MCCAMMON, ID	13	27	35	42	•	24	04-22-69	11
13075000	MARSH C NR MCCAMMON, ID	294	476	585	680	780	1120	02-12-62	23
13075600	N F POCATELLO C NR POCATELLO, ID	21	46	62	75	•	57	03-13-71	11
13077700	GEORGE C NR YOST, UT	66	110	131	146	160	146	06-10-63	18
13078000	RAFT R AT PETERSON RH NR BRIDGE, ID	130	430	828	1390	2270	2060	01-17-71	24
13079000	CLEAR C NR NAF, ID	121	226	278	317	355	386	06-15-67	28
13079200	CASSIA C NR ELBA, ID	163	438	642	827	•	982	12-23-64	11
13079800	HEGLAR CANYON TRIBUTARY NR ROCKLAND, ID	117	396	652	916	1260	1930	07- -58	16
13082500	GOOSE C AB TRAPPER NR OAKLEY, ID	300	810	1360	2140	3280	3240	02-11-62	64
13083000	TRAPPER C NR OAKLEY, ID	58	105	142	173	216	270	08-17-41	61
13092000	ROCK C NR ROCK CREEK, ID	197	420	538	625	712	461	05-19-70	36
13105000	SALMON FALLS C NR SAN JACINTO, NV	760	1560	2200	3000	4300	2430	05-18-75	65
13108500	CAMAS C AT 18 M SHEARING CORRAL NR KILGORE, ID	870	1640	2020	2310	2590	2590	05-08-69	29
13112900	HUNTLEY CANYON AT SPENCER, ID	10	23	30	36	•	36	05-15-69	10

Data Table B14. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft³/s							
STA_NO	STA_NAME	_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
13113000	BEAVER C AT SPENCER, ID	321	570	702	803	906	1190	05-18-75	21
13116000	MEDICINE LODGE C AT ELLIS RCH NR ARGORA, ID	105.0	192	241	279	320	361	04-15-62	31
13117000	BIRCH C NR RENO, ID	100.0	125	137	145	154	220	04-01-62	16
13117200	MAIN FORK NR GOLDBURG, ID	134.0	238	288	324	•	273	06-12-65	10
13117300	SAWMILL C NR GOLDBURG, ID	164.0	650	788	888	•	651	06-12-65	13
13118700	LITTLE LOST R BLW WET C NR HOWE, ID	307.0	490	574	632	687	609	06-16-75	17
13120000	N F BIG LOST R AT WILDHORSE NR CHILLY, ID	733.0	1150	1360	1500	1650	1420	06-12-65	34
13120500	BIG LOST R AT HOWELL RANCH NR CHILLY, ID	2120.0	3400	3930	4290	4620	4420	05-25-67	74
13128900	LOWER CEDAR C AB DIVERSIONS NR MACKAY, ID	155.0	247	289	318	•	256	06-08-72	11
13135200	PRAIRIE C NR KETCHUM, ID	167.0	285	314	380	•	293	05-24-63	10
13135500	BIG WOOD R NR KETCHUM, ID	891.0	1430	1690	1870	2050	1690	05-24-67	24
13135800	ADAMS GULCH DR KETCHUM, ID	40.0	113	161	199	•	124	1971	10
13141400	DEER C NR FAIRFIELD, ID	54.0	112	147	175	•	150	04-03-65	11
13141500	CAMAS C NR BLAINE, ID	2650.0	7150	9720	11700	13600	9780	04-08-43	53
13145700	SCHOOLER C NR GOODING, ID	23.0	55	76	93	112	68	02-01-63	16
13147900	LITTLE WOOD R AB HIGH FIVE C NR CAREY, ID	930.0	1800	2450	3200	4500	3000	12-22-55	41
13154000	CLOVER C NR BLISS, ID	1410.0	5160	8640	12200	16800	11000	12-22-64	24
13155200	BURNS GULCH NR GLENNS FERRY, ID	5.3	17	27	35	•	22	02-01-63	10
13155300	L CANYON C AT STOUT XING NR GLENNS FERRY, ID	88.0	230	338	438	555	500	12-23-64	15
13161100	BRUNEAU R NR CHARLESTON, NV	20.0	181	404	678	1080	1890	02-11-62	15
13161200	SEVENTY SIX C NR CHARLESTON, NV	24.0	74	108	136	166	89	05-00-75	15
13161300	MEADOW C NR ROWLAND, NV	180.0	533	1010	1380	1820	940	06-04-63	15
13161500	BRUNEAU R NR ROWLAND, NV	710.0	1580	2130	2590	3100	2120	02-11-62	22
13161600	MCDONALD C NR ROWLAND, NV	43.0	76	95	109	124	85	06- -75	16
13162200	JARBIDGE R AT JARBIDGE, NV	299.0	606	790	940	•	700	06- -70	15
13162400	BUCK C NR JARBIDGE, NV	79.0	261	410	550	•	380	06- -71	16
13162500	E F JARBIDGE R NR THREE CREEK, ID	436.0	735	894	1020	1140	798	06-22-71	22
13162600	COLUMBET C NR JARBIDGE, NV	11.0	35	52	69	88	46	05- -75	16
13167500	E F BRUNEAU R NR HOT SPRING, ID	194.0	486	687	861	1060	619	06-08-63	27
13169500	BIG JACKS C NR BRUNEAU, ID	162.0	712	1290	1940	2810	2100	01-22-43	23
13170000	L JACKS C NR BRUNEAU, ID	138.0	756	1430	2180	•	908	01-21-43	11
13170100	SUGAR C TRIBUTARY NR GRASMERE, ID	24.0	83	131	177	233	105	06-10-69	17
13172666	WEST FORK REYNOLDS C NR REYNOLDS, ID	4.7	13	20	25	•	14	06-02-75	14
13172668	EAST FORK REYNOLDS C NR REYNOLDS, ID	4.0	9	13	16	•	11	04-29-65	16
13172680	REYNOLDS C AT TOLLGATE WEIR NR REYNOLDS, ID	207.0	307	355	390	•	404	05-10-69	13
13172720	MACKS C NR REYNOLDS, ID	89.0	345	566	780	•	1200	12-23-64	15
13172735	SALMON C NR REYNOLDS, ID	75.0	269	429	580	•	1010	12-23-64	15
13172740	REYNOLDS C AT OUTLET WEIR NR REYNOLDS, ID	414.0	1460	2310	3110	•	3800	12-23-64	16
13172800	L SQUAW C TRIBUTARY NR MARSING, ID	9.0	45	80	117	164	93	01-31-63	17
13178000	JORDAN C AB LONE TREF C NR JORDAN VALLEY, OR	2050.0	3800	5000	6040	7470	7530	12-24-64	24
13184200	ROARING R NR ROCKY BAR, ID	326.0	537	635	704	•	575	06-22-67	14
13184800	BEAVER C NR LOWMAN, ID	102.0	182	224	257	•	195	1971	10
13185000	BOISE R NR TWIN SPRINGS, ID	7200.0	11300	13500	15000	16800	22700	1872	67
13186000	S F BOISE R NR FEATHERVILLE, ID	4550.0	6540	7380	7950	8490	7580	05-24-56	33
13186500	LIME C NR BENNETT, ID	649.0	1180	1470	1690	•	1180	04-27-52	11
13187000	FALL C NR ANDERSON RANCH DAM, ID	521.0	838	998	1120	•	1150	04-27-52	12
13191000	S F BOISE R NR LENOX, ID	4800.0	8540	10500	12000	13600	9550	04-17-43	35
13196500	BANNOCK C NR IDAHO CITY, ID	13.0	34	47	59	72	46	04-22-65	24
13200000	MORES C AB ROBIE CR NR ARROWROCK DAM, ID	2000.0	3880	5100	6080	7100	5270	04-08-43	62
13200500	ROBIE C NR ARROWROCK, ID	69.0	135	179	215	256	274	01-29-65	21
13207000	SPRING VALLEY C NR EAGLE, ID	51.0	241	442	663	•	435	02-11-79	16
13207500	DRY C NR EAGLE, ID	93.0	386	649	908	•	373	01-29-65	14
13210300	BRYANS RUN NR BOISE, ID	67.0	217	334	440	565	420	01-16-71	19
13214000	MALHEUR R NR DREWSEY, OR	2080.0	5400	8080	11100	14900	12000	12-23-64	57

Data Table B14. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft^3/s							
STA_NO	STA_NAME	_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
13216500	N F MALHEUR R AB BEULAH RES. NR BEULAH, OR	860.0	1900	2910	4000	5360	5910	03-20-10	41
13226500	BULLY C AT WARMSPRINGS NR VALE, OR	1280.0	4350	6910	9540	12800	12800	02-24-57	53
13234300	FIVEMILE C NR LOWMAN, ID	145.0	253	312	358	•	520	06-17-74	14
13235000	S F PAYETTE R AT LOWMAN, ID	4220.0	6010	6780	7310	7810	8980	06-16-74	37
13235100	ROCK C AT LOWMAN ID	150.0	310	404	480	•	400	05-13-71	10
13237300	DANSKIN C NR GRIMES PASS, ID	34.0	69	90	106	•	71	04-22265	10
13238300	DEEP C NR MCCALL, ID	349.0	490	553	597	•	540	06-06-70	10
13240000	LAKE FORK PAYETTE R AB JUMBO C NR MCCALL, ID	1360.0	2120	2460	2690	2910	2770	06-26-71	52
13245400	TRIPOD C AT SMITHS FERRY, ID	84.0	160	203	237	•	183	1971	16
13248900	COTTONWOOD C NR HORSESHOE BEND, ID	68.0	170	244	311	•	303	02-01-63	17
13250600	BIG WILLOW C NR EMMETT, ID	814.0	1490	1860	2150	2450	2100	12-22-64	18
13250650	FOURMILE C NR EMMETT, ID	90.0	367	578	764	•	500	12-22-64	10
13251300	W BRANCH WEISER R NR TAMARACK, ID	38.0	74	94	110	126	87	05-04-71	18
13251500	WEISER R AT TAMARACK, ID	480.0	800	945	1060	1200	1320	12-22-55	37
13252500	EF WEISER R NR COUNCIL, ID	56.0	71	76	80	•	77	06-16-38	10
13253500	WEISER R AT STARKEY, ID	992.0	1940	2480	2920	•	2800	12-22-55	12
13257000	MF WEISER R NR MESA, ID	778.0	1290	1540	1720	1890	1710	12-22-55	19
13258500	WEISER R NR CAMBRIDGE, ID	4880.0	8000	9790	11300	12800	10100	12-22-55	39
13260000	PINE C NR CAMBRIDGE, ID	260.0	498	632	737	847	850	02-25-58	24
13261000	LITTLE WEISER R NR INDIAN VALLEY, ID	790.0	1250	1550	1820	2120	1840	02-04-25	39
13263500	WEISER R AB CRANE C NR WEISER, ID	7700.0	13500	16400	19300	22400	19800	12-23-55	69
13266000	WEISER R NR WEISER, ID	9780.0	17500	21600	24700	27900	23500	12-23-55	58
13267000	MANN C NR WEISER, ID	412.0	790	1110	1460	1880	1540	03-27-40	32
13267100	DEER C NR MIDVALE, ID	61.0	152	211	262	•	156	01-27-70	10
13269300	N F BURNT R NR WHITNEY, OR	693.0	1050	1220	1340	•	1190	04-06-71	13
13270800	S F BURNT R ABOVE BARNEY C NR UNITY, OR	75.0	150	190	220	•	186	04-29-65	14
13273000	BURNT R NR HEREFORD, OR	659.0	1440	1890	2240	2610	2220	04-17-43	28
13275500	PPOWDER R NR BAKER, OR	706.0	1290	1580	1800	2010	1860	1921	52
13288200	EAGLE C ABOVE SKULL C NR NEW BRIDGE, OR	2030.0	3230	3850	4310	4780	5310	07-12-75	23
13290150	M PINE C NR HOMESTEAD, OR	72.0	185	262	328	•	226	04-30-65	13
13290190	PINE C NR OXBOW, OR	2740.0	6360	8650	10600	•	7110	02-21-68	13
13292000	IMNAHA R AT IMNAHA, OR	2600.0	4800	6450	8190	11500	10100	01-17-74	49
13292500	SALMON R NR OBSIDIAN, ID	518.0	714	794	849	•	721	05-29-52	12
13293000	ALTURAS LAKE C NR OBSIDIAN, ID	469.0	658	736	789	•	633	06-07-52	12
13295000	VALLEY C AT STANLEY, ID	990.0	1540	1780	1950	2110	2000	05-24-56	56
13295500	SALMON R BELOW VALLEY C AT STANLEY, ID	3050.0	4650	5350	5830	6290	5660	06-17-74	35
13296000	YANKEE FORK SALMON R NR CLAYTON, ID	1480.0	2790	3490	4020	4550	4900	06-17-74	28
13296500	SALMON R BELOW YANKEE FORK NR CLAYTON, ID	5040.0	8170	9530	10500	11300	10500	06-17-74	56
13297300	HOLMAN C NR CLAYTON, ID	9.1	20	25	30	•	25	06-13-65	10
13298000	E F SALMON R NR CLAYTON, ID	1510.0	2900	3620	4160	4710	4020	06-17-74	15
13298300	MALM GULCH NR CLAYTON, ID	85.0	391	672	948	•	440	04-01-69	10
13299000	CHALLIS C NR CHALLIS, ID	260.0	455	552	624	696	872	06-12-65	27
13301700	MORSE C ABOVE DIVERSIONS NR MAY, ID	142.0	228	267	295	•	270	06-16-75	14
13305700	DAHLONEGA C AT GIBBONVILLE, ID	98.0	211	272	319	•	235	1971	10
13305800	HUGHES C NR NORTH FORK, ID	138.0	256	320	268	417	250	01-16-74	17
13306500	PANTHER C NR SHOUP, ID	1780.0	3050	3630	4050	4440	3050	06-16-74	33
13308500	M F SALMON R NR CAPE HORN, ID	1650.0	2510	2890	3150	3390	3320	06-17-74	44
13309000	BEAR VALLEY C NR CAPE HORN, ID	2100.0	3210	3700	4040	4360	3860	05-27-56	39
13310000	BIG CREEK NR BIG CREEK, ID	3740.0	5380	6070	6540	•	5800	06-03-48	14
13310500	S F SALMON R NR KNOX, ID	1040.0	1500	1690	1830	1950	1620	05-27-56	31
13311000	E F SOUTH FORK SALMON R AT STIBNITE, ID	174.0	261	299	326	•	369	05-14-33	14
13311500	EF SOUTH FORK SALMON R NR STIBNITE, ID	356.0	559	698	775	•	783	06-15-33	12
13312000	E F SOUTH FORK SALMON R NR YELLOW PINE, ID	942.0	1370	1550	1670	•	2050	06-14-33	15
13313000	JOHNSON C AT YELLOW PINE, ID	3020.0	4630	5350	5850	6340	6230	06-17-74	49

Data Table B14. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft^3/s							
STA_NO	STA_NAME	_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
13313500	SECESH R NR BURGDORF, ID	1410.0	2000	2250	2420	•	2500	06-03-48	10
13314000	S F SALMON R NR WARREN, ID	11600.0	17300	19800	21500	•	23000	05-28-48	12
13315500	MUD C NR TAMARACK, ID	199.0	335	405	458	511	395	04-27-52	26
13316500	LITTLE SALMON R AT RIGGINS, ID	5180	8040	9490	10600	11600	12600	06-17-74	27
13316800	N F SKOOKUMCHUCK C NR WHITE BIRD, ID	129	231	289	335	384	471	06-08-64	12
13317200	JOHNS C NR GRANGEVILLE, ID	97	309	472	621	•	400	01-29-65	12
13319000	GRANDE RONDE R AT LAGRANDE, OR	3290	5900	7700	9600	12000	14100	01-30-65	69
13320000	CATHRINE C NR UNION, OR	764	1190	1380	1520	1660	1740	05-27-48	56
13323600	INDIAN C NR IMBLER, OR	405	637	752	838	•	818	05-27-48	13
13325000	E F WALLOWA R NR JOSEPH, OR	105	190	239	278	319	450	07-25-37	53
13329500	HURRICANE C NR JOSEPH, OR	537	858	1010	1130	1240	1110	06-09-48	55
13330000	LOSTINE R NR LOSTINE, OR	1580	2200	2470	2650	2810	2550	06-16-74	53
13330500	BEAR C NR WALLOWA, OR	912	1400	1630	1800	1970	1730	06-15-74	55
13331500	MINAM R AT MINAM, OR	3280	5100	5980	6620	7260	6260	06-16-74	13
13334700	ASOTIN C BELOW KEARNEY GULCH NR ASOTIN, WA	362	1040	1660	2300	3130	3700	01-15-74	49
13336500	SELWAY R NR LOWELL, ID	26200	39000	45100	49500	53800	48900	05-29-48	49
13336600	SWIFTWATER C NR LOWELL, ID	72	145	188	221	•	150	01-29-65	10
13336650	EF PAPOOSE C NR POWELL RANGER STA, ID	78	125	148	166	•	125	04-20-65	10
13336850	WEIR C NR POWELL RANGER STATION, ID	264	526	677	796	•	500	05-20-64	10
13336900	FISH C NR LOWELL, ID	1630	2400	2760	3020	•	2280	05-20-64	10
13337000	LOCHSA R NR LOWELL, ID	19300	28700	33000	36100	39100	35100	06-08-64	50
13337200	RED HORSE C NR ELK CITY, ID	89	177	228	268	•	200	05-21-64	10
13337500	S F CLEARWATER R NR ELK CITY, ID	1910	3130	3750	4210	4670	4040	06-08-64	30
13337700	PEASLEY C NR GOLDEN, ID	79	169	224	268	•	240	06-08-64	14
13338000	S F CLEARWATER R NR GRANGEVILLE, ID	5030	8140	9860	11200	12700	15000	05-30-17	51
13338200	SALLY ANN C NR STITES, ID	184	292	348	390	•	305	06-08-64	11
13339700	CANAL GULCH C AT PIERCE RANGER STATION, ID	116	230	298	352	•	291	04-20-65	16
13339900	DEER C NR OROFINO, ID	96	306	473	629	•	485	01-29-65	15
13340500	N F CLEARWATER R AT BUNGALOW R S, ID	16300	23000	26100	28400	30700	27400	05-29-48	25
13341000	N F CLEARWATER R NR AHSAHKA, ID	31500	48000	60000	75200	98500	100000	12-23-33	58
13341100	COLD SPRINGS C NR CRAIGMONT, ID	47	155	244	328	429	200	01-29-65	15
13341300	BLOOM C NR BOVILL, ID	55	113	150	180	213	151	12-24-64	18
13341400	E F POTLATCH R NR BOVILL, ID	633	1130	1410	1630	•	1740	12-23-64	12
13341500	POTLATCH C AT KENDRICK, ID	6380	11600	14500	16900	19400	16000	01-29-65	30
13343800	MEADOW C NR CENTRAL FERRY, WA	600	2240	3680	5080	•	2380	09-13-66	13
13344500	TUCANNON R NR STARBUCK, WA	1850	5470	8180	10600	13500	7980	12-22-64	24
13344700	DEEP C TRIBUTARY NR POTLATCH, ID	56	103	130	152	•	157	12-23-64	11
13344800	DEEP C NR POTLATCH, ID	726	1480	1950	2340	•	2330	01-16-74	16
13345000	PALOUSE R NR POTLATCH, ID	3460	6070	7560	8740	•	10100	01-16-74	16
13346100	PALOUSE R AT COLFAX, WA	4620	8550	10800	12700	14600	12600	01-16-74	21
13348000	S F PALOUSE R AT PULLMAN, WA	1050	2610	3750	4770	5970	5000	02-26-48	30
13348500	MISSOURI FLAT C AT PULLMAN, WA	387	813	1120	1390	1720	1500	02-26-48	23
13349210	PALOUSE R BELOW SOUTH FORK AT COLFAX, WA	6750	14400	19300	23500	•	16800	01-16-74	14
13349400	PINE C AT PINE CITY, WA	1920	5080	7400	9500	•	10600	02-03-63	15
13350500	UNION FLAT C NR COLFAX, WA	877	2010	2770	3420	4150	2930	01-29-65	23
13352500	COW C AT HOOPER, WA	114	496	876	1280	1800	1250	02-05-52	17
14010000	S F WALLA WALLA R NR MILTON, OR	783	1490	1940	2320	2730	2530	01-29-65	56
14013000	MILL C NR WALLA WALLA, WA	918	1940	2600	3160	3780	3680	01-29-65	41
14013500	BLUE C NR WALLA WALLA, WA	314	733	1010	1240	1500	1320	01-06-69	31
14016500	E F TOUCHET R NR DAYTON, WA	1100	2310	3090	3750	4480	5450	12-23-64	21
14017500	TOUCHET R NR TOUCHET, WA	3860	8080	10800	13100	15600	15100	1965	13
14018500	WALLA WALLA R NR TOUCHET, WA	7370	15500	20700	25100	30000	33400	12-22-64	26

Descriptions and a brief explanation of computation procedures for the basin characteristics are given below.

1. Drainage Area (DA)

   Drainage area is expressed in square miles, is the total area contributing to flood discharge, and is planimetered from U.S. Geological Survey topographic maps.

2. Drainage Area Below 6,000-Foot Altitude (PL6T)

   Drainage area below 6,000-foot altitude is expressed as a percentage of the total drainage area and is obtained by outlining the 6,000-foot contour and planimetering the subbasin.

3. Forest Cover (F)

   Forest cover is expressed as a percentage of the drainage covered by forests and is obtained by a grid-overlay method. The grid is selected so that approximately 30 intersections are within the basin. The number of intersections within forested areas are then counted and expressed as a percentage of all intersections.

4. Length

   Length is the total distance, expressed in miles, along the main channel between the divide and the gage.

5. Slope (S)

   Slope is the average fall in the main channel, expressed in feet per mile, in a reach from the 10th to the 85th percentile of the length upstream from the gage.

6. Mean Altitude (ALT)

   Mean altitude, expressed in feet, is computed by a grid-overlay method. The grid selected should have at least 20 points inside the basin. (This may not be possible for very small basins.) Altitudes at the intersection points are then averaged.

7. Mean Annual Precipitation (MAP)

   Mean annual precipitation, expressed in inches, is computed by a grid-overlay method on a 1930-1957 mean annual precipitation map (National Oceanic and Atmospheric Administra¬tion, 1965). The grid selected should have at least 20 points inside the basin. (This may not be possible for very small basins.) Precipitation at the intersection points is then averaged.

8. Precipitation Intensity for 24 Hours With a 50 Percent Exceedance Probability (INT24HR)

   Precipitation intensity, expressed in inches, is computed by using a grid-overlay method and a map of isopluvials of 2-year, 24-hour precipitation (National Oceanic and Atmospheric Administration, 1973, or Harenberg, 1980).

9. Mean Minimum January Temperature (MMJT)

   Mean minimum January temperature, expressed in degrees Fahrenheit, is determined from a map (Figure B-16) based on the period 1931-1952 (National Oceanic and Atmospheric Administration, 1971).

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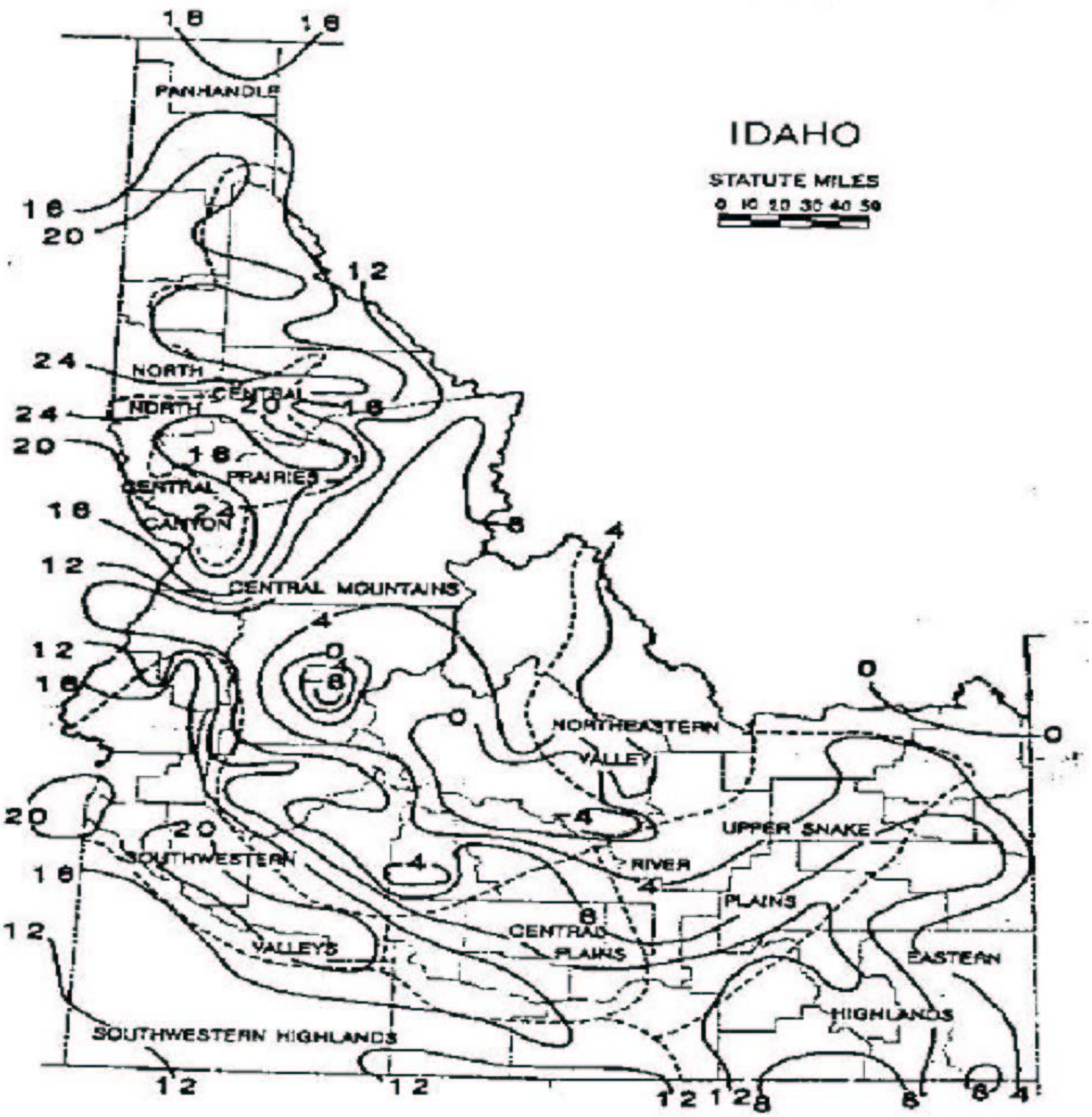
Figure B-16

Mean Minimum Temperature (F.), January



Based on period 1931 — 52
Isolines are drawn through points of approximately equal value.
Caution should be used in interpolating on these maps, particularly in mountainous areas.

The regression equations were used to estimate the standard deviation and mean of the logarithms of annual peak discharges for each gaging station in the study area. The generalized skew coeffi¬cient previously determined for each station was used to obtain a value for the log-Pearson Type III frequency factor – a function of the skew coefficient and exceedance probability (Bulletin 17A, appendix 3) – at the 2 percent exceedance probability. The log-Pearson equation was then com¬puted and the results were compared with the discharge listed in the data in Figure B-14, based on the gaging-station record. This comparison, which indicates the relative accuracy of the regression equations, is expressed as the standard error of estimate. For a large sample, two out of every three observations can be expected to be within one standard error. The standard error, in percent, for the 2 percent exceedance probability is shown in Figure B-13 for each set of equations. The lost degrees of freedom in computing the standard error were obtained by summing the number of constants in each regression equation and adding one for the skew coefficient.

The regression equations should be used only for streams that have some homogeneity with the streams that defined the equations. Regression equations are not well defined for very small drainage basins and it is not recommended that equations be used for drainage areas less than 0.5 square miles. Also, the regression equations are poorly defined in a range of about 1,500 to 2,000 square miles and are undefined above that range. The regression equations would not apply to streams that are ephemeral, that are subject to intensive thunderstorms, or that drain areas significantly affected by man's activities. Streams that drain unforested basins or that flow through alluvial valleys may also be poorly defined.

The following is a series of steps employed to estimate the discharge at a given exceedance probability for an ungaged site, using Spring Valley Creek near Eagle, Idaho (13207000) as an example (Figure B-15).

Step 1: Locate the drainage basin in Figure B-15 and determine the region in which it is located (in this case, region 2).

Step 2: From Figure B-13 determine the equations to be used from the basin size and compute the mean and standard deviation of logarithms of annual peak discharges. For the example given, drainage area, mean annual precipitation, and altitude are 20.9 square miles, 14 inches, and 3,990 feet, respectively. Mean logarithm is 2.026 and standard deviation of the logarithms is 0.354.

Step 3: The annual peak discharge can be caused by snowmelt or rainstorm runoff because the drainage basin is completely below 6,000 feet and the mean altitude is 3,990 feet. Therefore, sheet 3 of Figure B-17 is used to identify the generalized skew coefficient (G), which, in this case, is 0.

Step 4: For a log-Pearson Type III variable at exceedance probability (P_e):

$$\text{Log } Q_{Pe} = M + K_{Pe} S \qquad (3)$$

Here, M = 2.026; S = 0.354. From data table F, at P_e = 0.02 and G = 0, K is 2.054; therefore:

$$\text{Log } Q = 2.026 + 2.054\ (0.354) \qquad (4)$$

and

$Q = 566$ ft^3/s (5)

where

Q = discharge

M = Mean log of annual maximum discharge.

S = Standard Deviation

Step 5: Compare with nearby gaging stations (Figure B-15). In this case, Dry Creek near Eagle, Idaho (13207500), drainage area 59.4 square miles, and Bryans Run near Boise, Idaho (13210300), drainage area 7.94 square miles, have runoffs of 15.3 (ft^3/s)/mi^2 and 55.4 (ft^3/s)/mi^2, respectively. The 27.1 (ft^3/s)/mi^2 runoff from Spring Valley Creek appears to be reasonable from this comparison.

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U.S. ARMY CORPS OF ENGINEERS,
U.S. BUREAU OF RECLAMATION,
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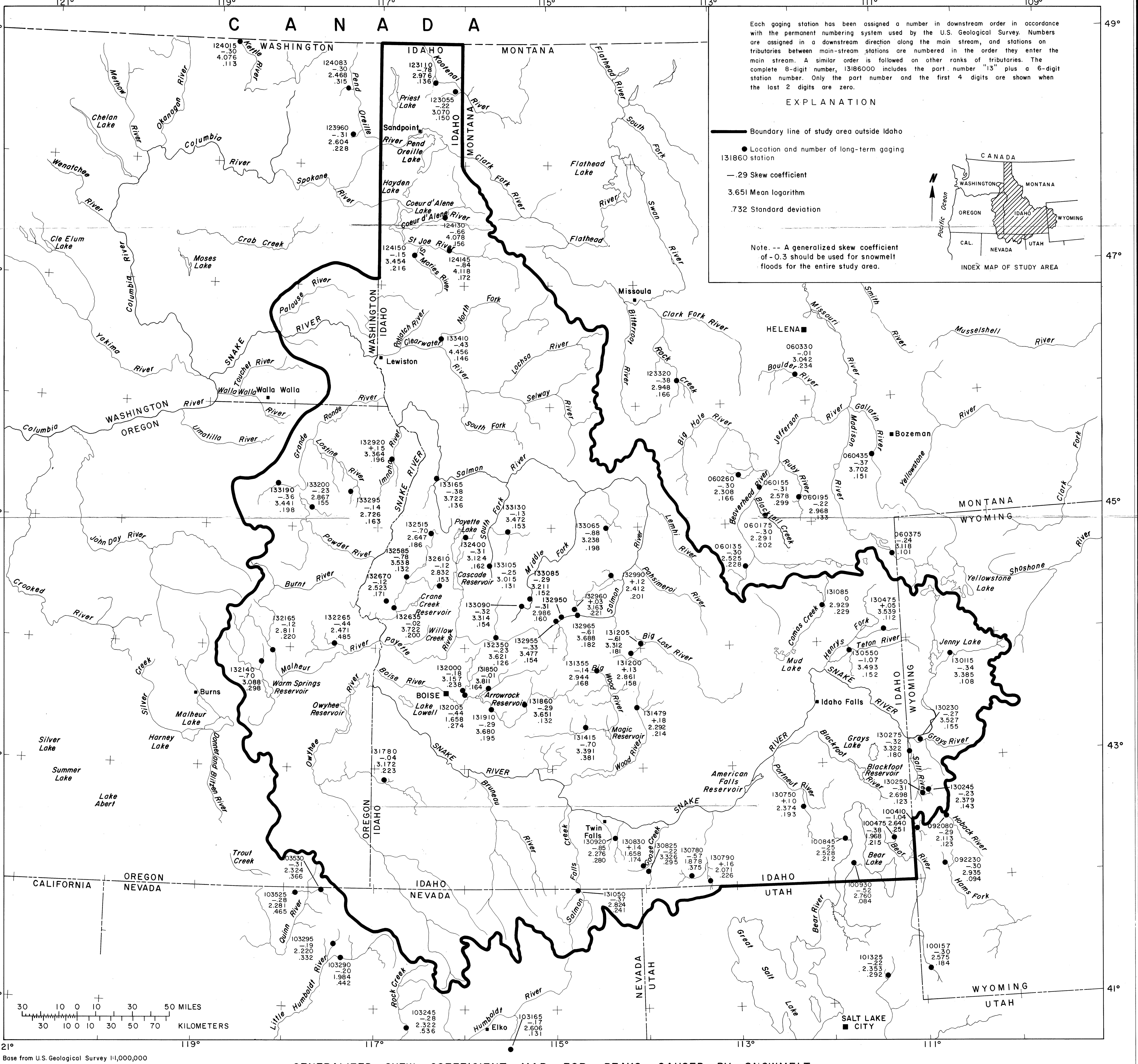
AND IDAHO TRANSPORTATION DEPARTMENT

OPEN-FILE REPORT 81-909
PLATE 1



GENERALIZED SKEW COEFFICIENT MAP FOR PEAKS CAUSED BY SNOWMELT

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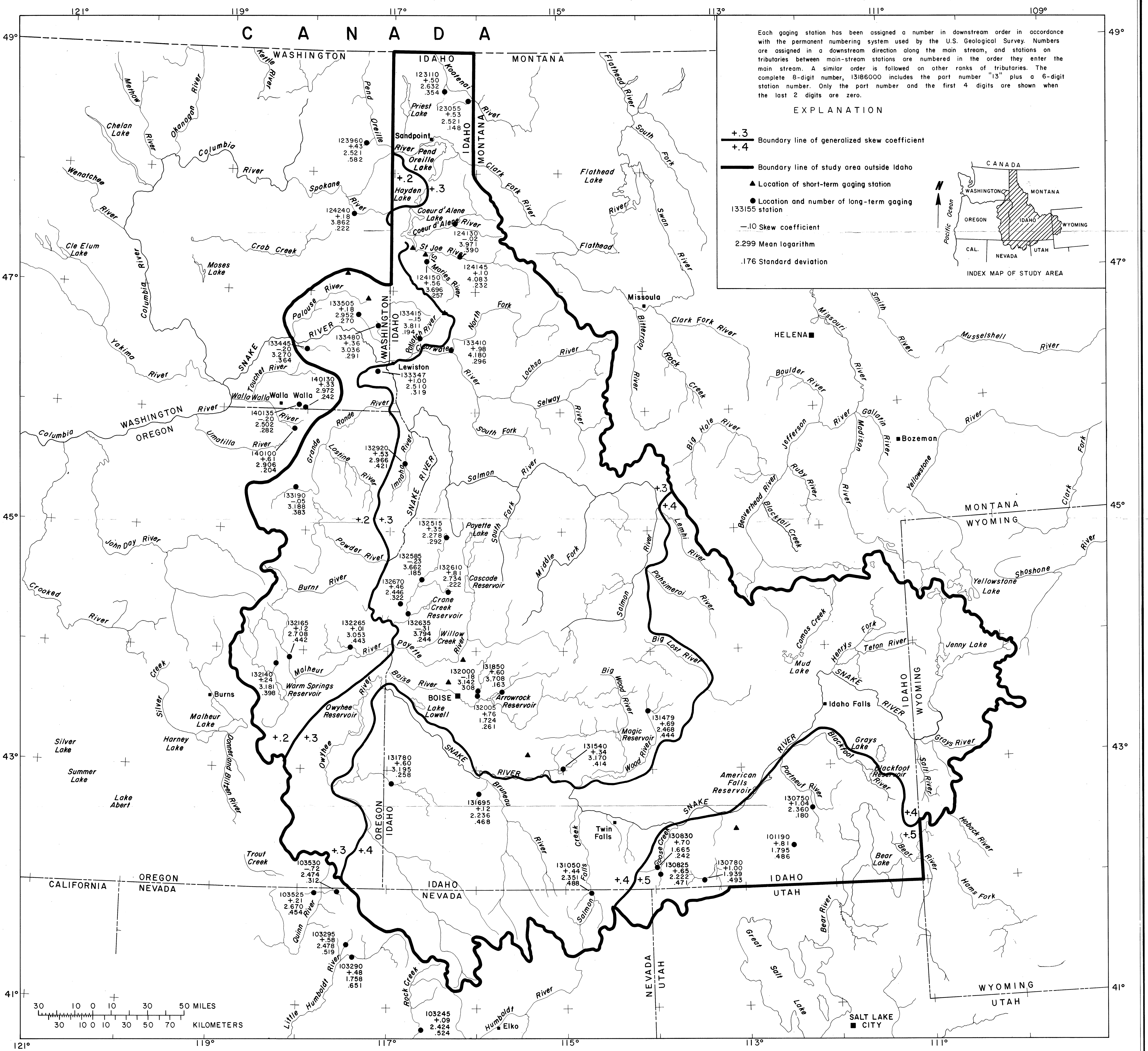
OPEN-FILE REPORT 81-909
PLATE 2



Base from U.S. Geological Survey 1:1,000,000
Columbia River Basin, 1948

GENERALIZED SKEW COEFFICIENT MAP FOR PEAKS CAUSED BY RAINSTORMS

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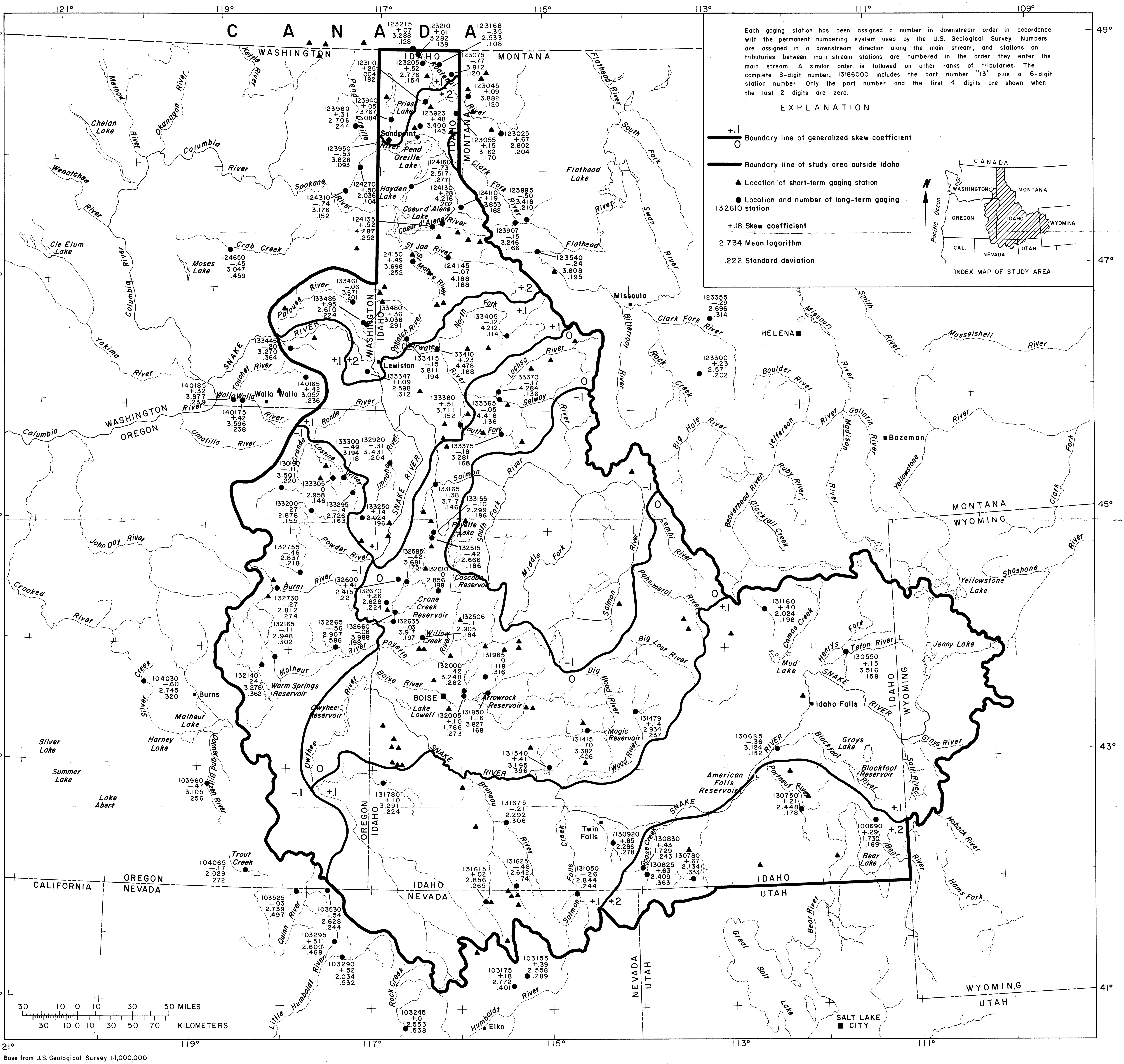
AND IDAHO TRANSPORTATION DEPARTMENT

OPEN-FILE REPORT 81-909
PLATE 3



Base from U.S. Geological Survey 1:1,000,000
Columbia River Basin, 1948

GENERALIZED SKEW COEFFICIENT MAP FOR ANNUAL MAXIMUM PEAKS CAUSED BY EITHER SNOWMELT OR RAINSTORMS

Summary and Conclusions

Generalized skew coefficient maps (Sheets 1, 2, and 3 of Figure B-17) were prepared for the study area for (1) snowmelt, (2) rainstorm, and (3) snowmelt or rainstorm floods. Average skew coefficients for gaging stations shown on each of the skew maps are indicative of the differences in skew coefficients resulting from separate analysis of flood types. Skew values determined from the three categories of floods mentioned above averaged -0.31, 0.17, and -0.05, respectively. The values used to compute each of these averages are, however, widely spaced and have standard deviations of 0.27, 0.32, and 0.38, respectively.

Generalized skew maps for peaks caused by rainstorms and annual maximum peaks caused by either snowmelt or rainstorms were made by plotting the station skews and determining a regional pattern. Most of the generalized skew boundary lines coincide with hydrologic unit boundaries (U.S. Geological Survey, 1975). In attempting to develop a method to estimate generalized skew, regression equations using basin characteristics did not adequately define variability of the skew coefficient.

Generalized skew coefficients range from +0.2 to +0.5 for analysis of rainstorm floods, and -0.1 to +0.2 for analysis of annual maximum peaks caused by either snowmelt or rainstorms. Although the skew maps provide considerably different values, some consistency between the findings of this study and the generalized skew coefficient map in Bulletin 17A should be noted. Bulletin 17A applies a generalized skew coefficient of -0.3 to much of Idaho. This coefficient was based on gaging stations having 25 or more years of record. In developing the Bulletin 17A skew map, greater weight was given to long-term record stations. The floods at many of these long-term stations are caused only by snowmelt. Thus, the skew on the Bulletin 17A map would seem to correspond to the generalized skew obtained for snowmelt floods in the present study.

The generalized skew coefficients on Sheets 1 and 2 of Figure B-17 should be used only where the annual maximum peak is dominated by one type of flood or where separate snowmelt and rainstorm flood arrays are available for analysis. At stations where it is not possible to develop separate flood arrays, the annual maximum peaks and the generalized skew coefficients from Sheet 3 of Figure B-17 should be used.

Percentage of drainage area below 6,000-foot altitude can be used as a guideline for determining the type of flood. Except for the southwestern corner of the study area, stations having less than 20 percent of drainage area below 6,000 feet should be considered as being dominated by snowmelt floods. Except for southeastern Washington, few gaging stations were observed to be dominated by rainstorm floods. The generalized skew coefficient map for rainstorm floods (Sheet 2 of Figure B-17) should be used when a combined frequency curve for both types of floods is being prepared or where the mean altitude of the basin is below 3,000 feet.

B.50 – OPEN CHANNELS AND BRIDGES

B.50.01 Field Data Cross Sections for Backwater Computations. An example of this procedure is illustrated in an application to the Red Fox River, Colorado. Figure B-18 is a plan view showing the river, contours on the flood plain, and the location and alignment of cross sections. The stream flows from west to east. Cross sections are plotted in Figure B-19. The cross sections start at some point downstream and progress upstream. They are measured from left to right when looking downstream. The data will be more adaptable if some reference distance such as 500 is assigned to the low point of the channel.

The location and alignment of cross sections are very important because they describe the geometric model that is the basis for the entire series of computations. Contour lines are used in orienting sections perpendicular to the expected current directions, and the results often require angle points to model both channel and overbank flow. In this example, no cross sections intersect. In cases where cross sections do tend to cross, the cross section alignments should run parallel to each other to high ground and some small, positive value should be assigned for each reach length. Zero reach lengths should be avoided so that dividing by zero will not occur in subsequent computations.

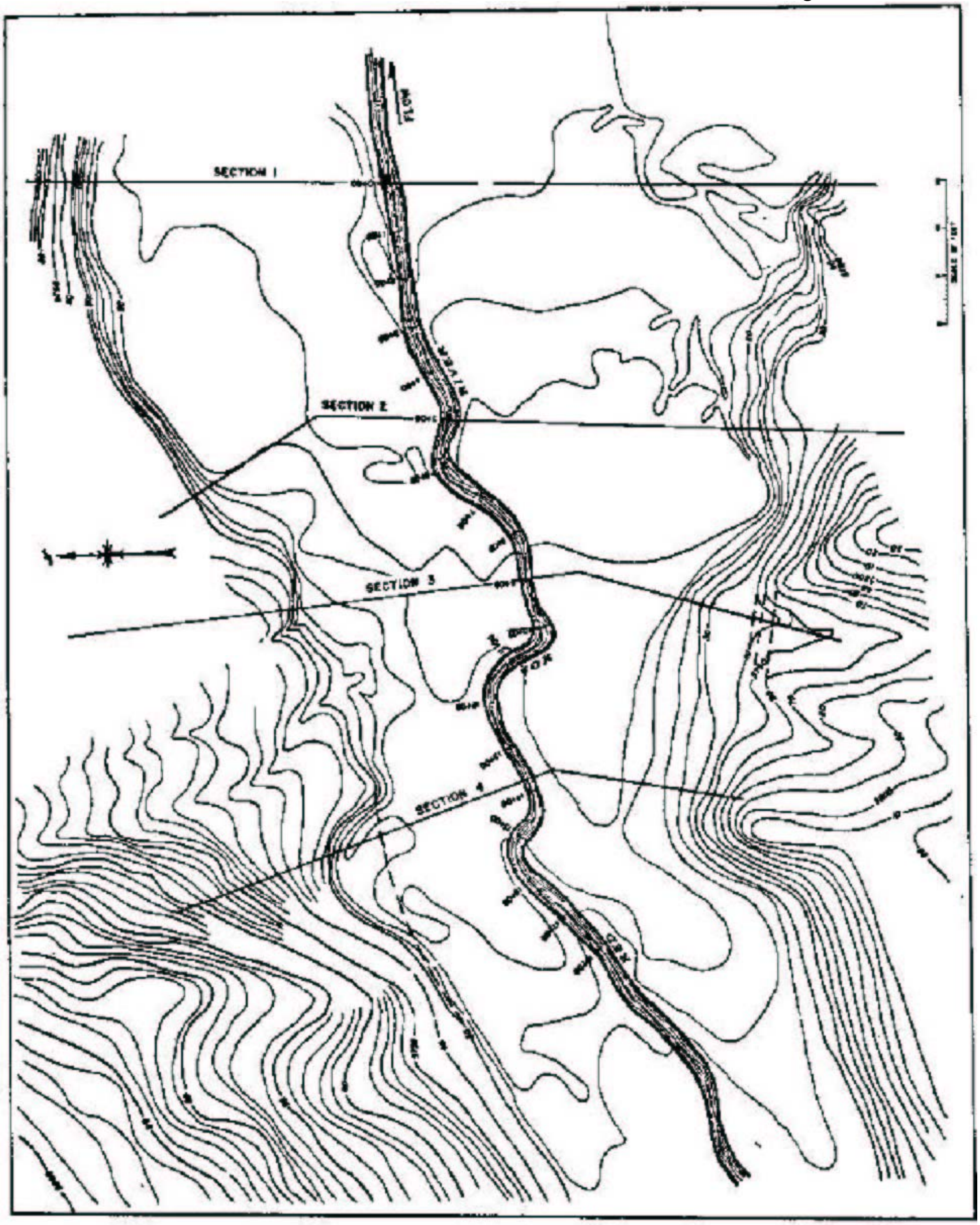
Hydraulic roughness values or n values should be obtained from the field. Each cross section represents a reach of the river that extends half way to the next cross section in each direction. This should be kept in mind when determining the n values.

Examples of cross sections taken to measure a flood by the U.S. Geological Survey are shown in Figure B-21. The roughness values should be shown on each cross section, as they are helpful in locating where a cross section should be subdivided to determine distributed properties. Mannings n values (Chow, Open Channel Hydraulics 1959) are shown in Table B-5.

B.50.02 Hydrologic Regional Calculations. U.S. Geological Survey hydrologic regional equations can be computed using the National Flood Frequency (NFF) option under the HYDRAIN, HYDRO computer program

B.50.03 Hydraulic Backwater Calculations. Hydraulic backwater calculations for bridges over natural streams should be done using the Army Corps of Engineers, River Analysis System (HEC-RAS) computer program. Selected examples of riprap typical sections are given in Figure B-22, sheets 1 through 5.

Figure B-18



Plan view of the Red Fox River, Colorado

Figure B-19
Sheet 1 of 2

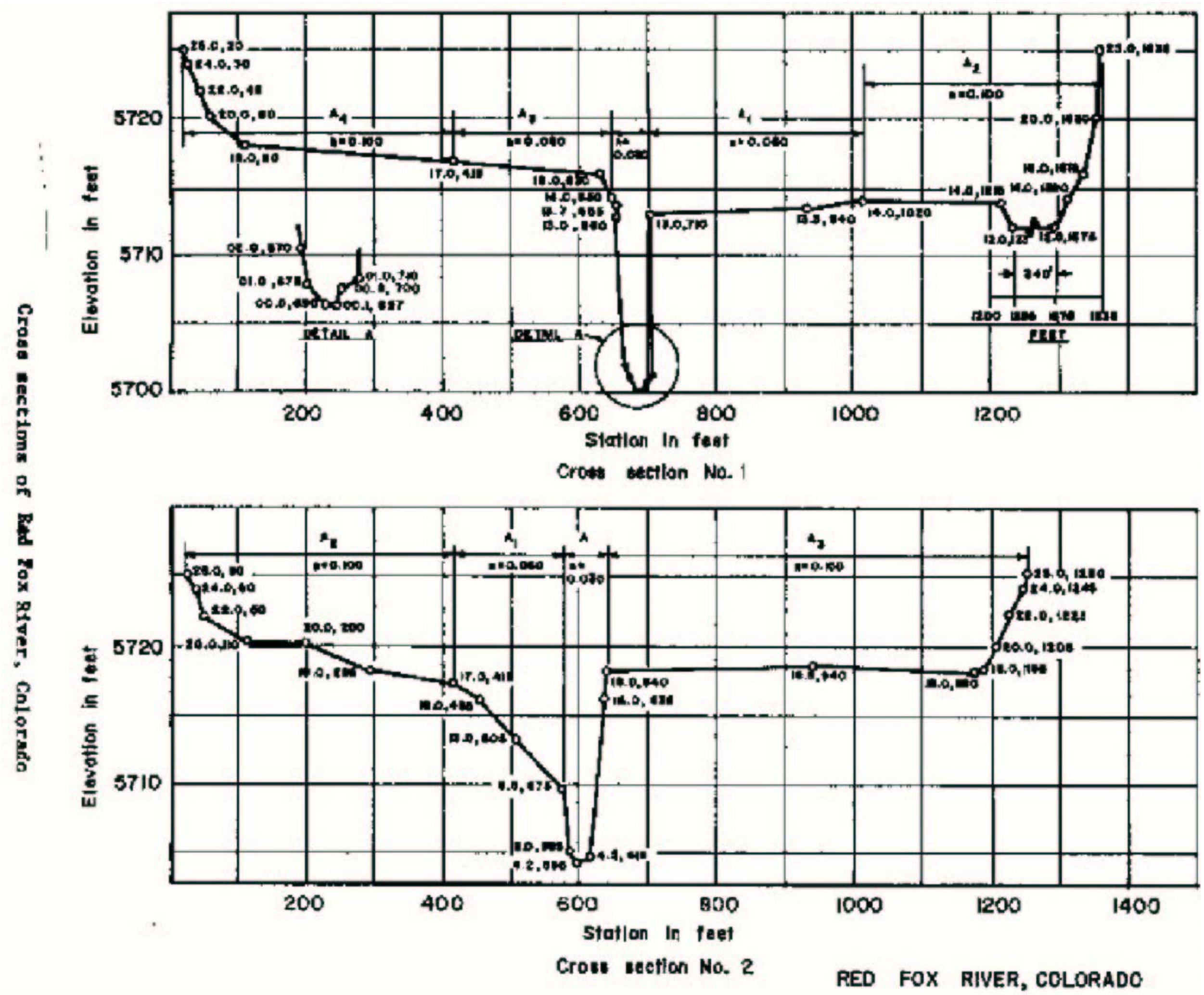
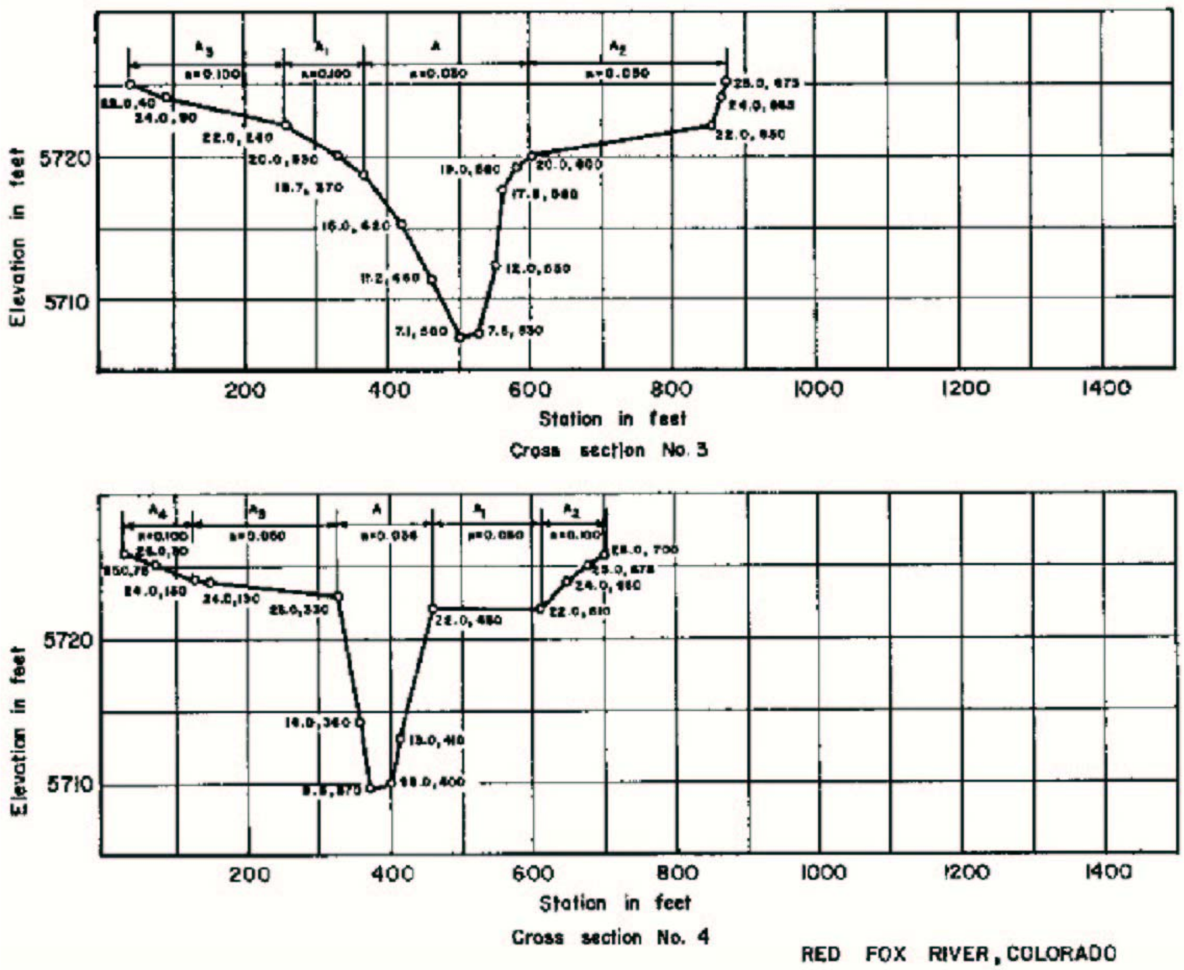


Figure B-19
Sheet 2 of 2



Cross sections of Red Fox River, Colorado (cont)

Figure B-20

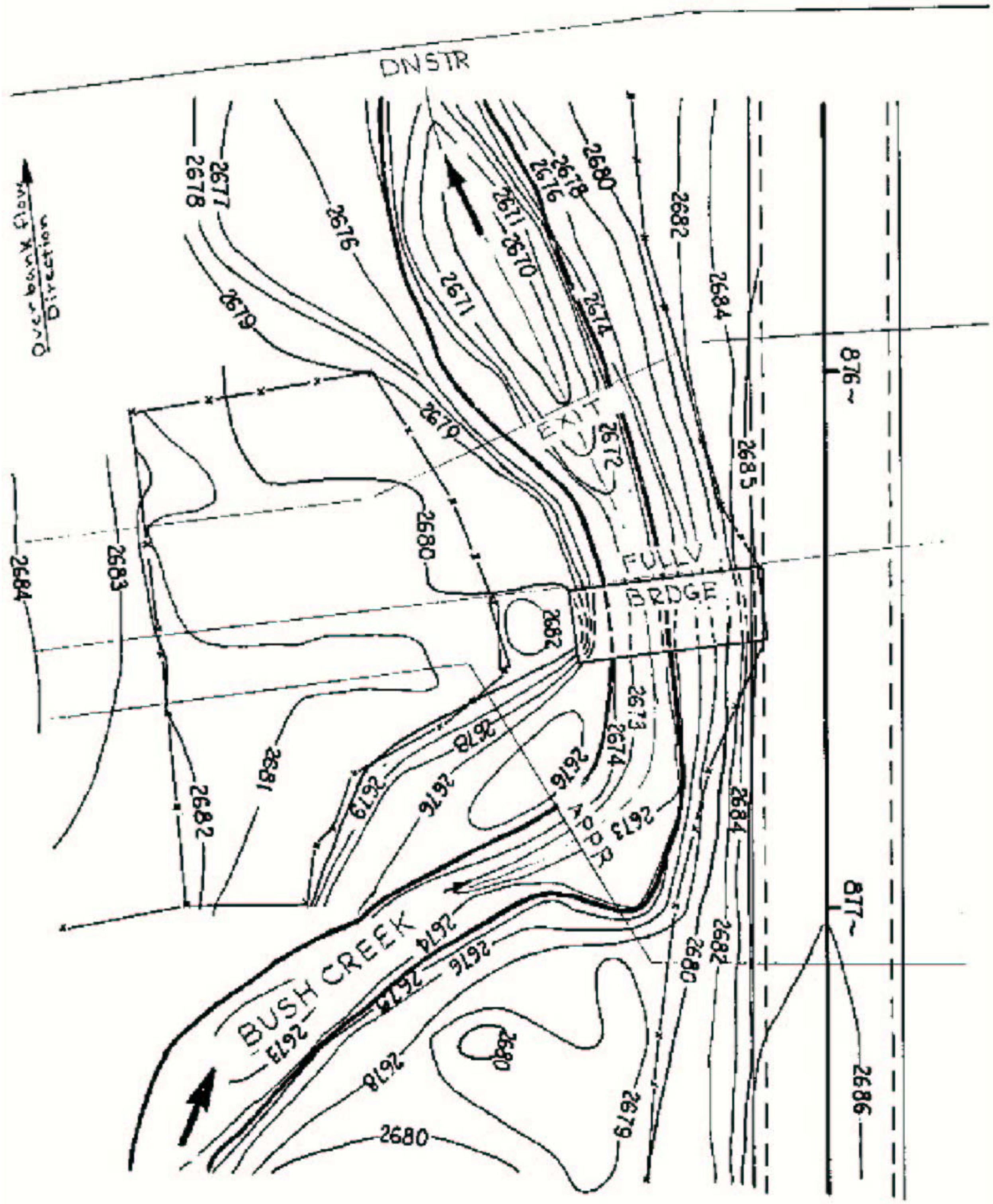

DNSTR
Overbank Flow Direction
EXIT
FULLY
BRDGE
APPR
BUSH CREEK
876~
877~
2680
2682
2684
2686

Figure B-21

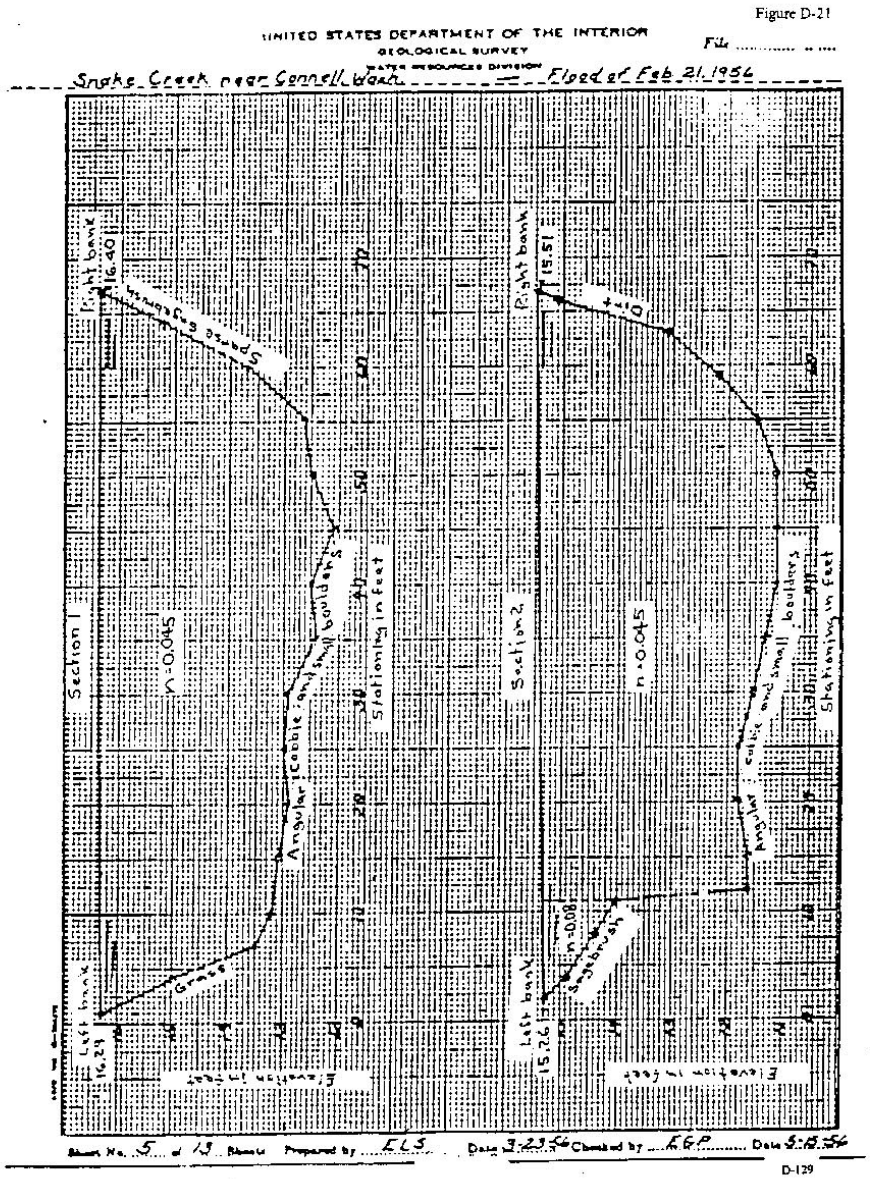


Figure D-21
UNITED STATES DEPARTMENT OF THE INTERIOR
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WATER RESOURCES DIVISION
Snake Creek near Connell, Wash. — Flood of Feb. 21, 1956
Section 1
n=0.045
Section 2
n=0.045
n=0.08
Stationing in feet
Elevation in feet
Left bank 16.29
Right bank 16.40
Left bank 15.26
Right bank 15.51
Grass
Sparse sagebrush
Angular cobble and small boulders
Dirt
Sagebrush
Sheet No. 5 of 13 Sheets Prepared by ELS Date 3-23-56 Checked by EGP Date 5-15-56
D-129

Table B-5 page 1 of 5

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
A. Lined or Built-up Channels			
A-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	0.012	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
A-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
A. Lined or Built-up Channels (continued)			
A-2. Nonmetal (continued)			
d. Concrete bottom float finished with sides of:			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	0.013	0.015
2. In cement mortar	0.012	0.015	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	....	0.500
B. Excavated or Dredged			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033

Table B-5 page 3 of 5

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
B. Excavated or Dredged (continued)			
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channel not maintained, weeds & brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
C. Natural Streams			
C-1. Minor streams (top width at flood stage less than 100 ft.)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools/shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060

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VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
C. Natural Stream (continued)s			
C-1. Minor streams (top width at flood stage <100 ft.) (continued)			
a. Streams on plain (continued)			
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways w/heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees & brush along banks submerged at high stages			
1. Bottom—gravels/cobbles/boulders	0.030	0.040	0.050
2. Bottom—cobbles w/large boulders	0.040	0.050	0.070
C-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees in winter	0.035	0.050	0.060
3. Light brush and trees in summer	0.040	0.060	0.080
4. Medium to dense brush, winter	0.045	0.070	0.110
5. Medium to dense brush, summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land w/tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but w/heavy growth of sprouts	0.050	0.060	0.080

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VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
C. Natural Stream (continued)			
C-2. Flood plains (continued)			
d. Trees (continued)			
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
C-3. Major streams (top width at flood stage >100 ft.), the n value is less than that for minor streams of similar description, because banks offer less effective resistance			
a. Regular section w/no boulders or brush	0.020	....	0.060
b. Irregular and rough section	0.035	....	0.100

B.60 – RIPRAP DETAILS

Figures B-22 to B-28 are to be used to determine riprap.

Figure B-22

Procedure for Determining if Filter Fabric is Required

1. Obtain sieve analysis of parent (base) material.
2. Plot Gradations on the following Gradation Curve Chart. (Figure B-23)
3. From the Gradation Curve Chart, determine the D_{15}, D_{50}, and D_{85} sizes.
4. Determine the D_{15}, D_{50}, and D_{85} riprap size as outlined in HEC-11 or HEC-18.
5. Determine if filter fabric is required from:

$$\frac{\mathbf{D_{15}\ Riprap}}{\mathbf{D_{85}\ Base}} < 5 < \qquad \frac{\mathbf{D_{15}\ Riprap}}{\mathbf{D_{15}\ Base}} < 40$$

$$\frac{\mathbf{D_{50}\ Riprap}}{\mathbf{D_{50}\ Base}} < 40$$

6. If the above *criteria is met*, no filter fabric is required.If the above criteria is not met, a filter fabric will be required.
7. Select approved filter fabric.

Figure B-23

Gradation Curve Chart

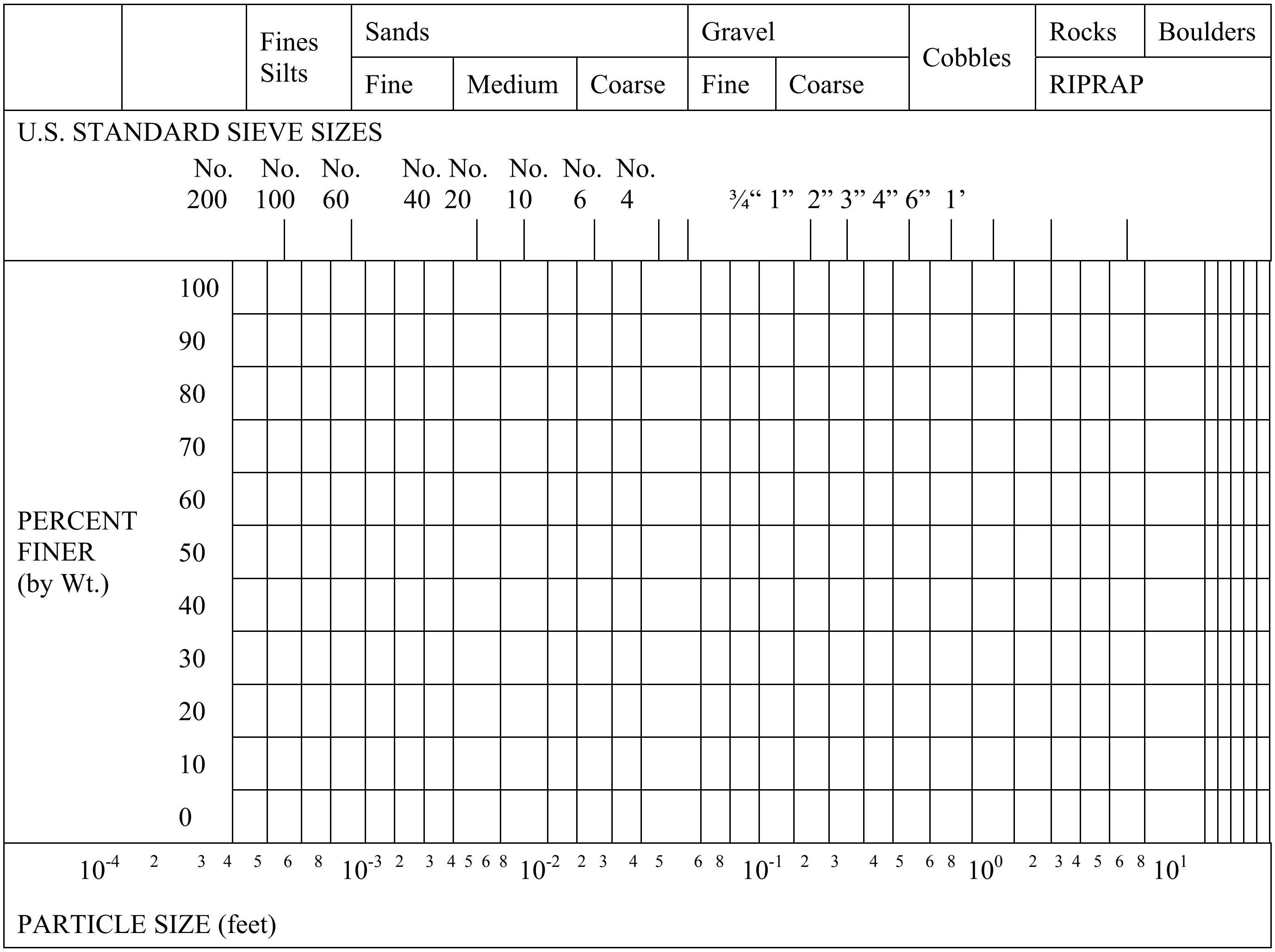

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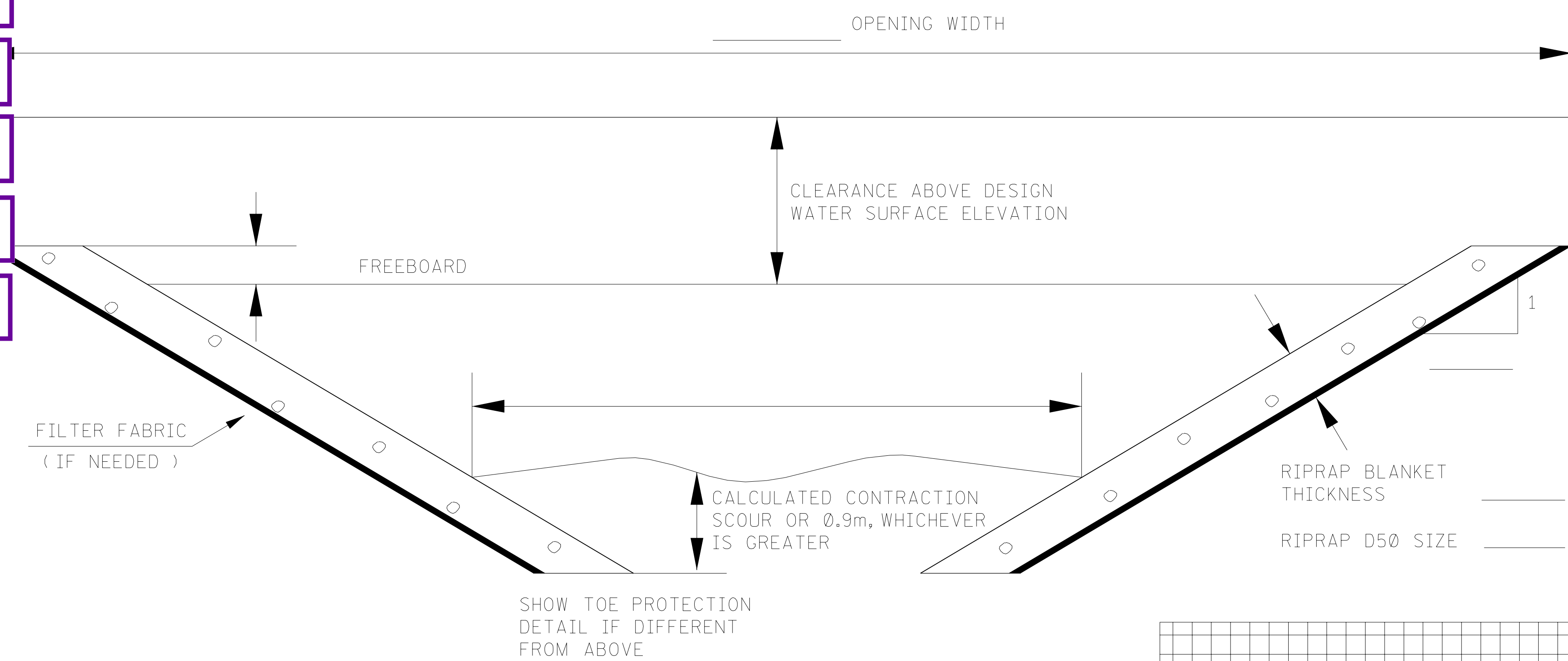
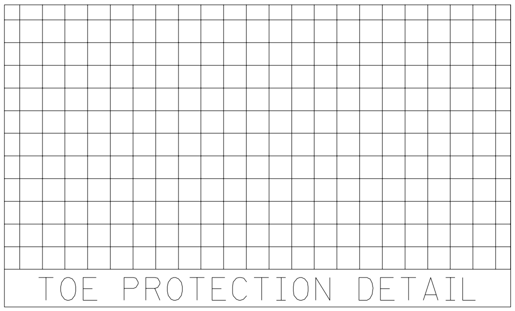
Figure B-24

TYPICAL SECTION
NORMAL TO CHANNEL



PROJECT DATA



CADD DWG. B_241098.dgn

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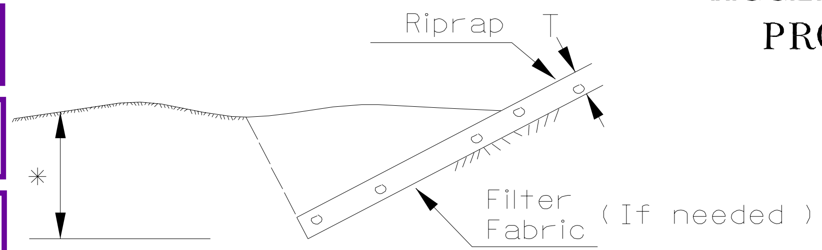
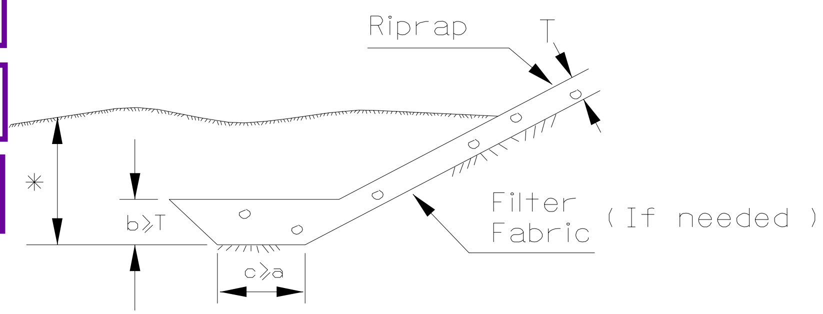
ACCEPTABLE TOE PROTECTION

Figure B–25

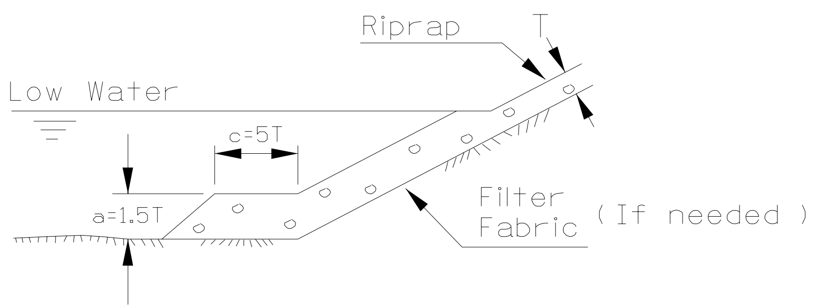


METHOD 1: This is most suited to areas where the toe is dry during construction

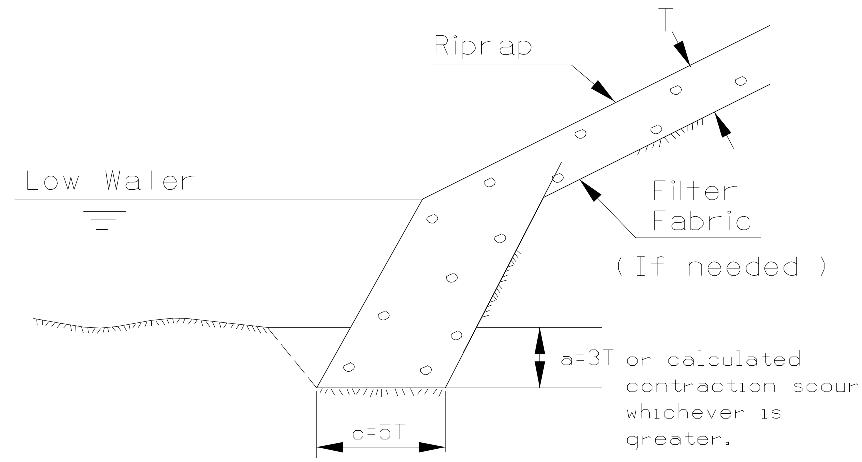
* Calculated contraction scour depth or 0.9m whichever is greater



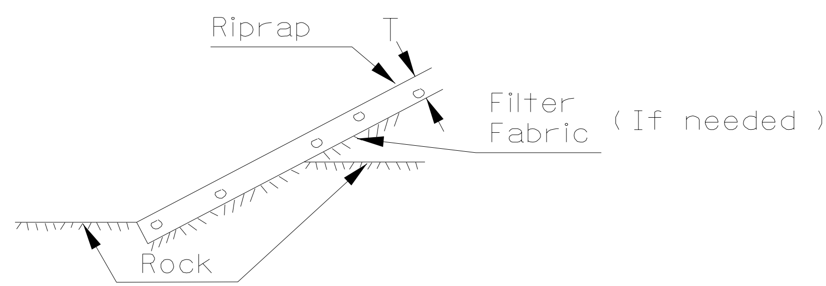
METHOD 2: Used when the streambed is very wet or groundwater present makes using Method 1 impractical.



METHOD 3: Often used when toe is underwater during construction. Both methods 2 and 3 utilize the idea that undermining will cause rock at the toe blanket to settle into the eroded area providing protection during scouring.



METHOD 4: Used underwater in areas with extremely bad streambed erosion conditions which make Method 3 infeasible. This method may also be preferred where Method 3 would destroy fish spawning beds.



METHOD 5: When the Streambed is non-erodible, no special provisions for toe protection are needed other than insuring that the riprap is well keyed into the rock.

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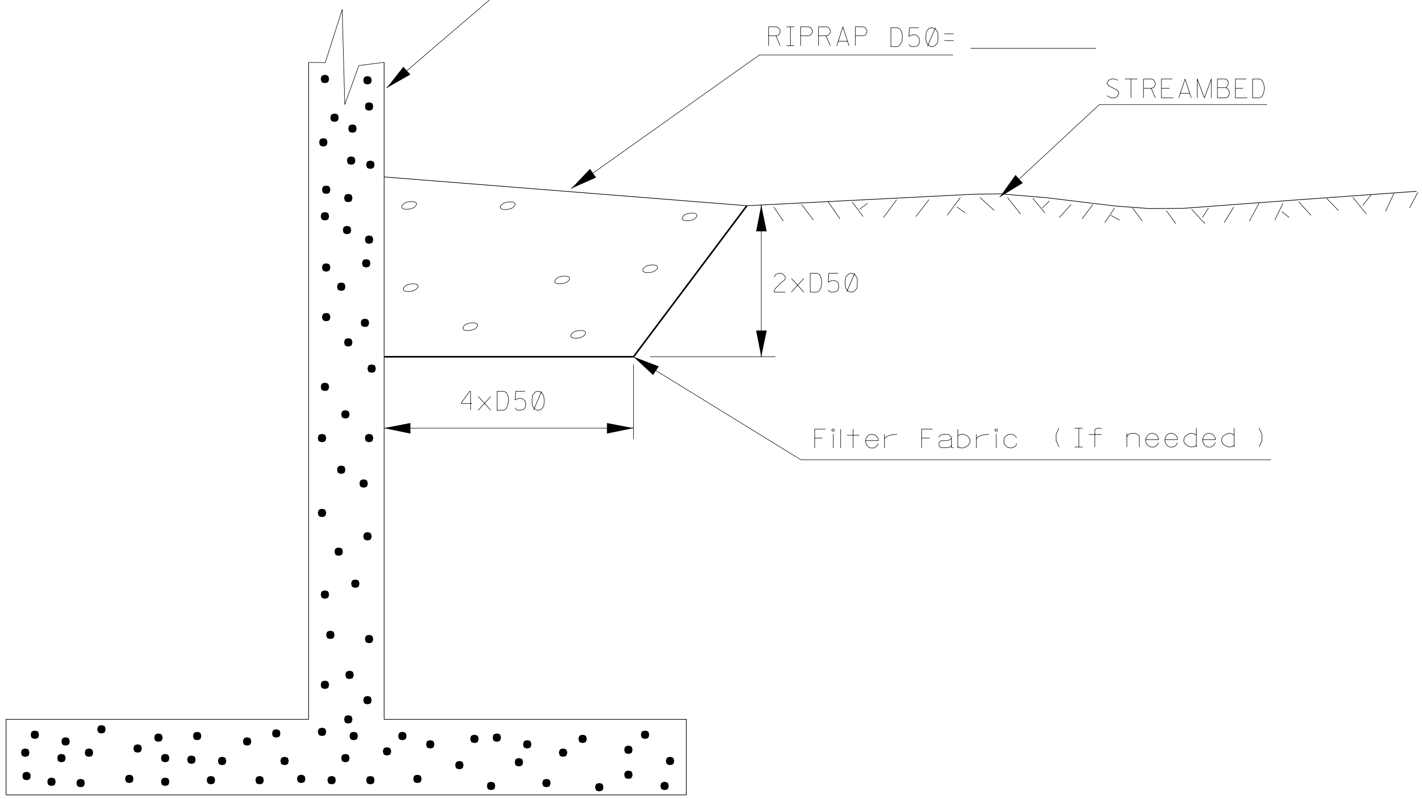
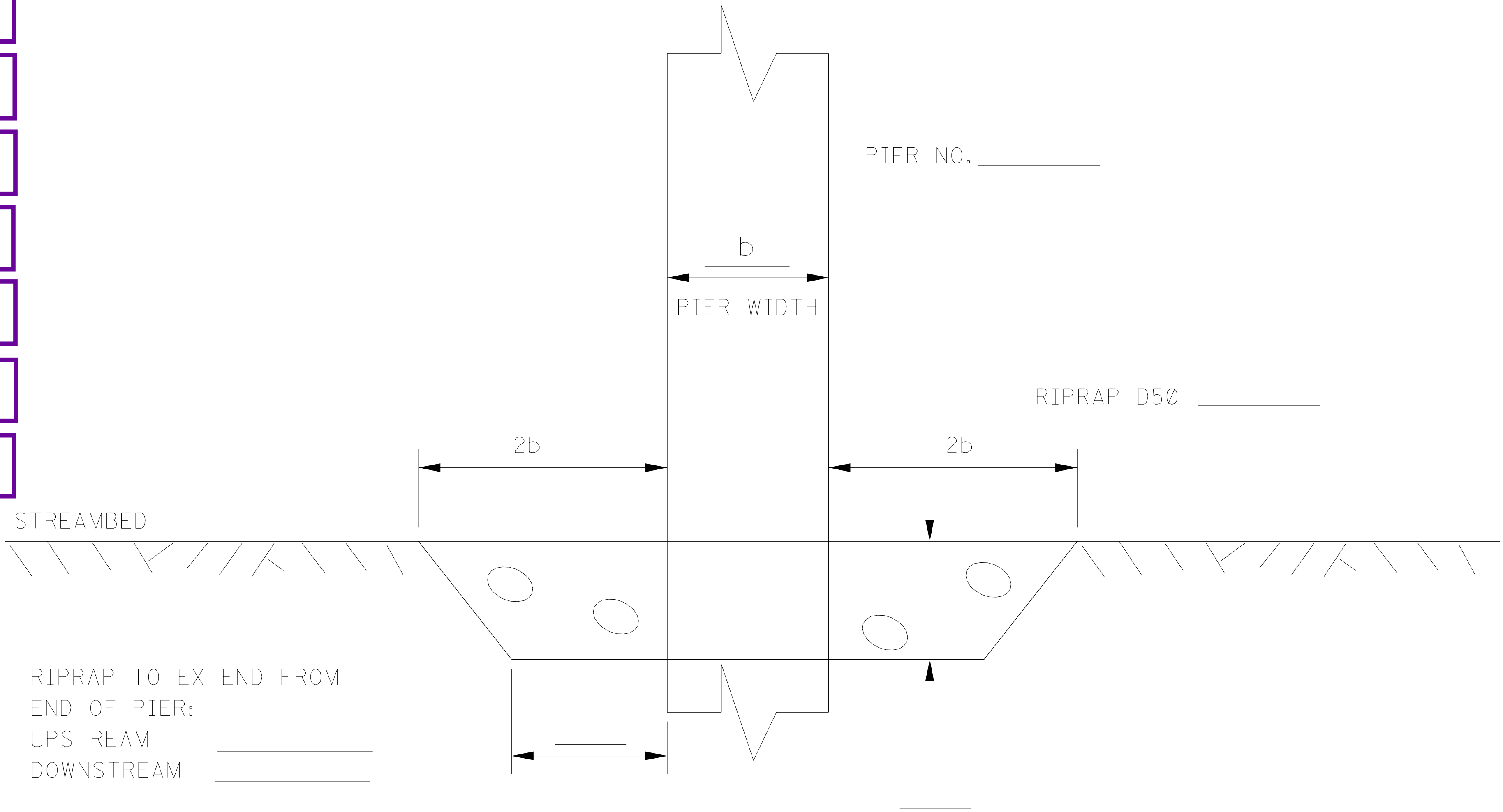
Figure B–26



RIPRAP DETAIL
FOR
VERTICAL ABUTMENT

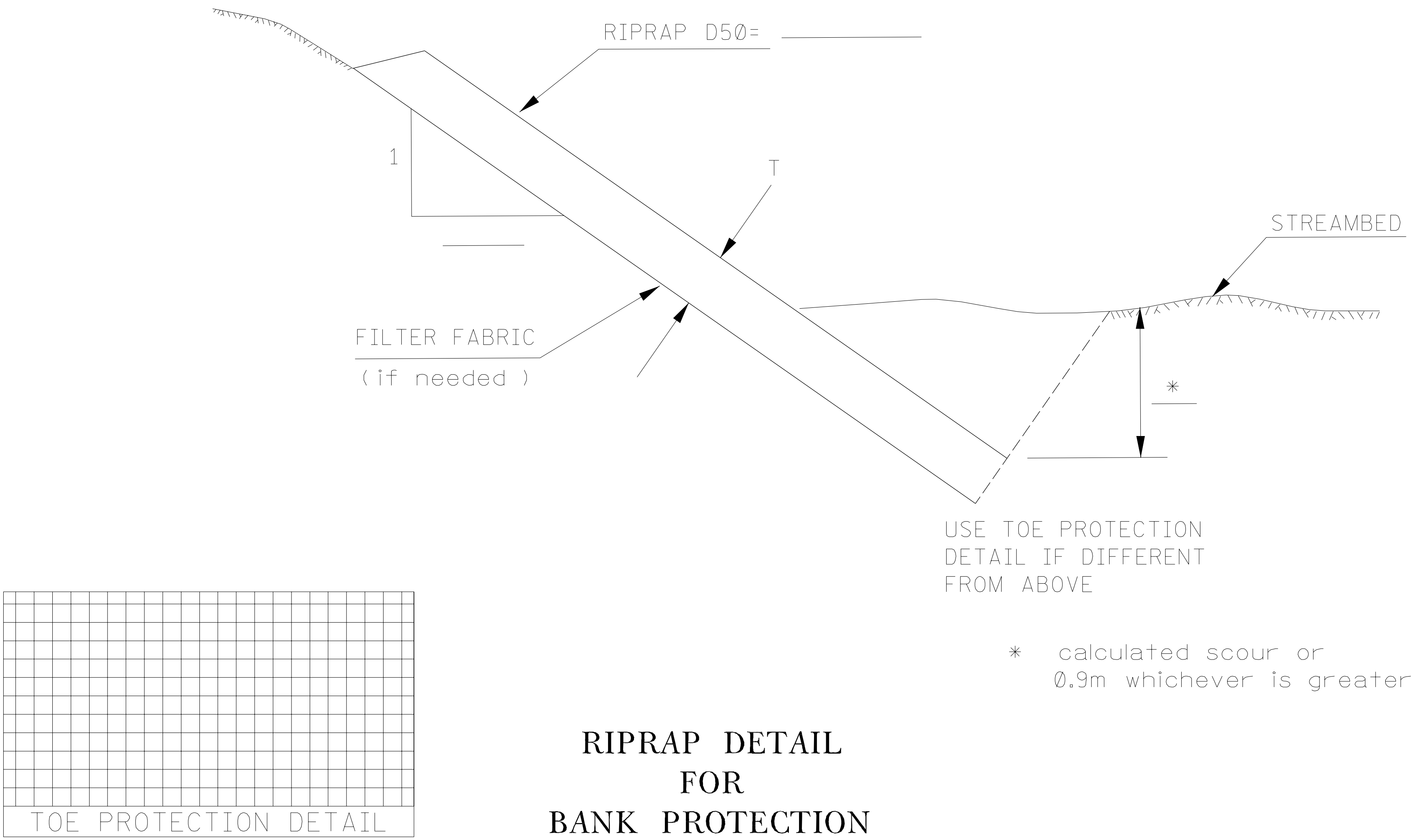
PIER PROTECTION

Figure B–27



PROJECT DATA

Figure B-28



* calculated scour or
Ø.9m whichever is greater

RIPRAP DETAIL
FOR
BANK PROTECTION